

3

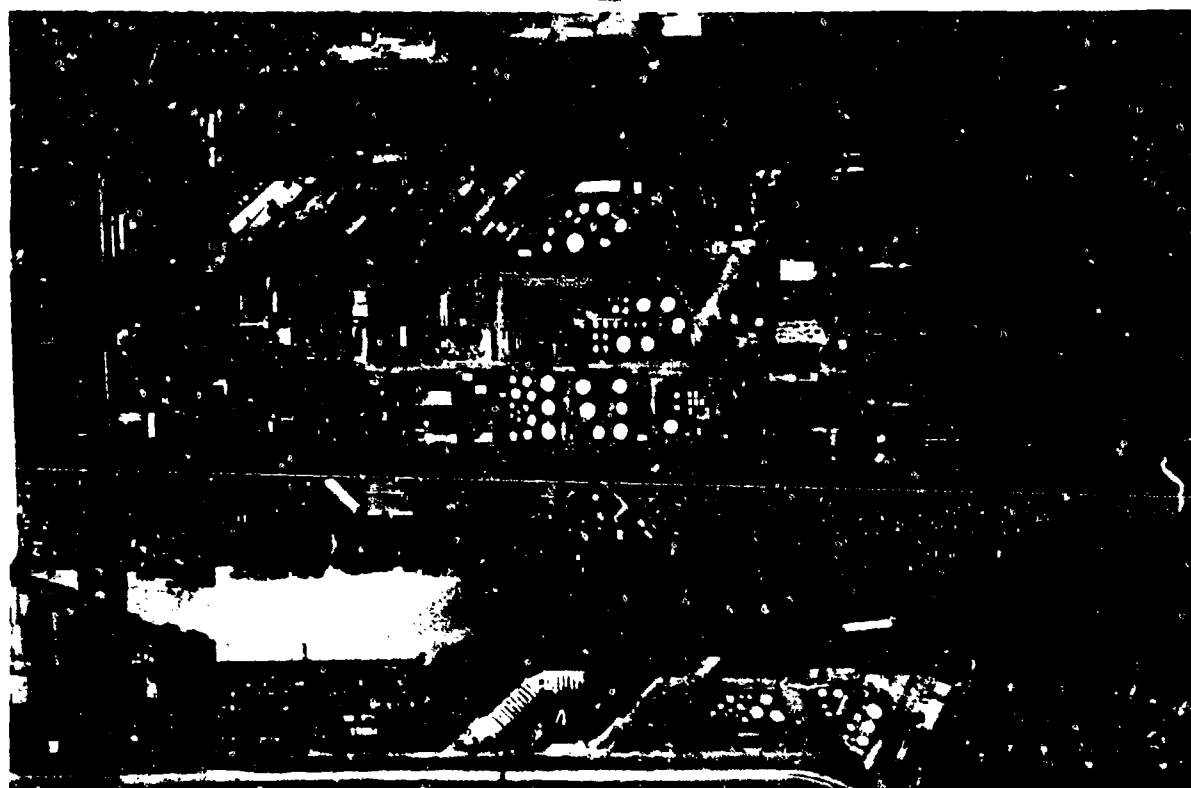
41

DUWAMISH WATERWAYS NAVIGATION IMPROVEMENT STUDY:

Review of Existing Information on Land-Use
Plans and Aquatic Resources in and Adjacent
to the Duwamish River and Elliott Bay,
Washington.

12 317

LEVEL II



AD A108852

DTIC FILE COPY

PREPARED BY
THE JOINT VENTURE OF
SHAPIRO AND ASSOCIATES, INC./PARAMETRIX, INC./DAN CHENEY
FOR

412308



U.S. ARMY CORPS OF ENGINEERS
SEATTLE DISTRICT

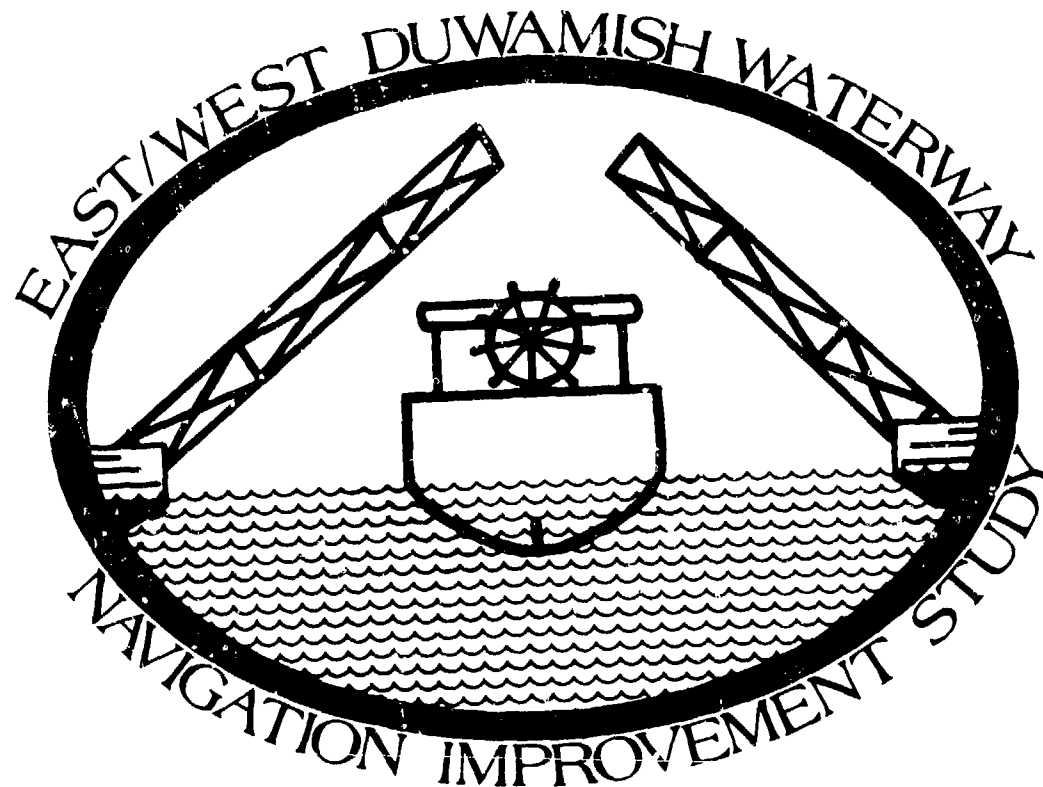
DTIC
ELECTE
DEC 23 1981

81 12 22 848

DISTRIBUTION STATEMENT A

Approved for public release
Distribution Unlimited

JUNE 1980



Cover Photograph: The aerial photograph of Harbor Island and the East and West Duwamish Waterways depicts the intense industrial and port related activities in the area. Harbor Island, created by earlier disposal of dredged materials, is located at the mouth of the Duwamish estuary where the estuary meets Elliott Bay. Photograph by Seattle District, Corps of Engineers.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
AD A408852		
4. TITLE (and Subtitle) Duwamish Waterway Navigation Improvement Study: Review of existing information on land use plans and aquatic resources in and adjacent to the Duwamish River and Elliott Bay, Washington		5. TYPE OF REPORT & PERIOD COVERED Final
7. AUTHOR(s)		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Shapiro & Assoc./Parametrix/Dan Cheney 812 Smith Tower/506 Second Ave Seattle, WA 98104		8. CONTRACT OR GRANT NUMBER(s) DACW67-78-C-0122
11. CONTROLLING OFFICE NAME AND ADDRESS Seattle District, Army Corps of Engineers P.O. Box C-3755/4735 E. Marginal Way South Seattle, WA 98124		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE June 1980
		13. NUMBER OF PAGES 309
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
LITERATURE SURVEYS	WATER QUALITY	WILDLIFE
WASHINGTON (STATE)	FISHERIES	AQUATIC BIOLOGY
DUWAMISH RIVER	INFORMATION CENTERS	SEATTLE HARBOR
LAND USE	GREEN RIVER	ELLIOTT BAY
HOWARD HANSON DAM	PHYTOPLANKTON	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
<p>As part of the study on the Duwamish River Navigation Improvement Project, this literature search was performed to compile and review all existing information and ongoing research on lands and natural resources that may be affected during the widening and deepening of the Duwamish Waterway. The area of interest included Seattle Harbor, Elliott Bay, the Duwamish River and Waterway, and the Duwamish-Green River system to Howard A. Hanson Dam.</p>		

Major information topics covered in the literature search include land use and development plans in the Lower Duwamish River and Seattle Harbor and water quality and aquatic resources upstream to Howard A. Hanson Dam.

Coordination with Federal, state and local government agencies allowed access to existing libraries and bibliographies on the study area. Unpublished information on file was accessed when available and current research activities were surveyed. City, University, and consultants' libraries were other major sources of literature.

Accession For	
NTIS	<input checked="" type="checkbox"/>
DTIC	<input type="checkbox"/>
Unpub	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

DTIC
FLECTE
S DEC 23 1981 D
D

FINAL

Duwamish Waterways Navigation Improvement Study: Review of
Existing Information on Land Use Plans and Aquatic Resources
In and Adjacent to the Duwamish River and Elliott Bay, Washington

Prepared for

Seattle District
U.S. Army Corps of Engineers

Prepared by

The Joint Venture of
Shapiro and Associates, Inc./Parametrix, Inc./Dan Cheney
812 Smith Tower
506 Second Avenue
Seattle, Washington 98104
(206) 624-9190

June 1980

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	ii
A. LAND USE	A-1 to A-89
Summary	A-2
Information Sources	A-3
Plans, Policies, and Related Documents	A-4
Surveys and Inventories	A-36
Environmental and Archaeological Assessments	A-47
Other	A-69
B. WATER QUALITY	B-1 to B-80
Summary	B-2
Information Sources	B-3
General Conditions	B-5
Dredging/Disposal and Fill Studies	B-32
Point Source Studies	B-55
Accidental Spills	B-78
C. FISHERIES	C-1 to C-33
Summary	C-2
Information Sources	C-3
Surveys and Inventories	C-4
D. OTHER AQUATIC RESOURCES	D-1 to A-47
Summary	D-2
Information Sources	D-3
E. BIBLIOGRAPHIES AND GENERAL INFORMATION	E-1 to E-23
Summary	E-2
Information Sources	E-3
F. DATA ON FILE	F-1 to F-37

INTRODUCTION

As part of a study on the Duwamish River Navigation Improvement Project, this literature search was performed to compile and review all existing information and on-going research on lands and natural resources that may be affected during the widening and deepening of the Duwamish Waterway. The area of interest included Seattle Harbor, Elliott Bay, the Duwamish River and Waterway, and the Duwamish-Green River system to Howard A. Hanson Dam.

Major information topics covered in the literature search include land use and development plans in the Lower Duwamish River and Seattle Harbor, and water quality and aquatic resources upstream to Howard A. Hanson Dam.

Coordination with federal, state, and local government agencies allowed access to existing libraries and bibliographies on the study area. Unpublished information on file was accessed when available and current research activities were surveyed. City, University, and consultants' libraries were other major sources of literature.

Each annotation has been evaluated for its relevance and completeness with respect to the objectives of this study. The scale utilized ranged from a high of 5 to a low of 1. The highest scale was given to reports with original data bases, specific to the project area. Reports with a low rating were either very general with respect to content and location or provided only a limited examination of pre-existing data. Articles were abstracted or the author's abstract was used when available. Abstracted information includes a summary of purpose, timing, methods, results, and conclusions of the document.

A. LAND USE

SUMMARY

There were three basic types of land use information available for the Duwamish Waterway: (1) governmental land use plans or policies, (2) inventories of land uses along the river, and (3) detailed site-specific studies for specific projects or actions along the river documented in environmental impact statements.

Notable among plans and policies are A Development Concept for the Duwamish Basin (Economic Council, 1974), and South Park Neighborhood Development Program (Naramore, Bain, Brady and Johanson, 1973). The Seattle and King County Shoreline Master Programs, along with their respective comprehensive plans and zoning codes, provide specific guidelines for Duwamish area development.

Fifteen Environmental Impact Statements or Assessments were located which were considered of significant value to this study. The Port of Seattle's EIS for Terminal 37 (Port of Seattle, 1976) and their EIS for Seattle Harbor Navigation Project (Port of Seattle, 1979) are very informative documents.

Much information was located that is not included in these categories. Archaeological studies for an area near Kellogg Island are included. Duwamish Diary (Cleveland High School, 1949) provides an historical perspective on land use in the basin. Several studies on transportation projects, including the West Seattle Bridge Location and Design Report (West Seattle Bridge Design Team, 1980) to an understanding of land use issues in the Duwamish area. An analysis of some of the political forces that affect the area and will shape its future can be found in the Position Statement and Analysis on the Duwamish Annexation Proposal of Tukwila (King County, Port of Seattle, and City of Seattle, 1974). Intra-Urban Industrial Location Patterns (P. Falchi, 1977) is a Master's Thesis from the University of Washington which uses specific examples from the Seattle/Duwamish area to document and explain theoretical industrial location choices and forces.

INFORMATION SOURCES

<u>Agency</u>	<u>Telephone Contact</u>	<u>Written Response</u>	<u>Personal Visit</u>
Port of Seattle	Yes	No	Yes
City of Seattle	Yes	Yes	Yes
King County	Yes	No	Yes
Economic Development Council	Yes	No	No
City of Tukwila	Yes	No	No
Department of Ecology	Yes	No	No
Department of Natural Resources	Yes	No	No
Bureau of Indian Affairs	Yes	No	No
Muckleshoot Indian Tribe	Yes	No	No
Duwamish Indian Tribe	Yes	No	No
The Boeing Company	Yes	No	No
Libraries:			
Gov. Research Assistance (GRA), (City of Seattle)	No	No	Yes
Port of Seattle	No	No	Yes
University of Washington	No	No	Yes
Shapiro and Associates, Inc. (SAI)	No	No	Yes

PLANS, POLICIES, AND RELATED DOCUMENTS

Economic Development Council, Seattle-King County. February 1974. A Development Concept for the Duwamish Basin. Economic Development Administration Technical Assistance Grant #07-6-09428. 3 Vol. in one binding, 110 pp.

Source of Information: GRA Library

Area of Study: Duwamish Basin

This report describes present (Circa 1974) land use and socioeconomic data, specifies growth and constraint factors and develops a conceptual strategy for overall development and growth in the 7,500 acre Duwamish Basin, from the southern edge of the Seattle Central Business District to the northern boundary of Tukwila. Industrial areas comprise 40% of the study area; the river and roads together represent about 30%; publicly owned land, including Port of Seattle facilities and Boeing Field total over 14% and railroads and residential areas represent about 6% each. Socioeconomic data are presented on area residents and employers/employees. Maritime activity is described in present and historical context, with unique features contributing to growth such as the waterway, and containerization and specific constraints on growth, such as parcel fragmentation, the high prices of land, and air pollution. Forecasts are made of future economic trends, future maritime and maritime-related growth, and discussions are presented of trade implications with Japan, the "publics" (e.g., residents, Metro, industries, etc.), public services, environmental requirements and vehicular transportation patterns. Conclusions and recommendations are made for conceptual issues of land assembly, economic use, pollution, residential activity, transportation, substitution and potential industry, and for land blocks such as the waterways, Boeing Field, Harbor Island, Georgetown, South Park, Allentown, railyards, and the Holgate Lander Subarea. Alternatives for the future are examined. Status quo will result in significant development, but problems of land assembly and intergovernmental "self-interests" would limit growth. A future called a "Compact for Planning" would allow a minimum of comprehensive planning. The report recommends the third alternative - the "Duwamish Area Industrial District", which would include the City and County with the Port in planning for future growth. An appendix is an economic impact evaluation of the development concept, which forecasts a direct job gain of 10,000 in the Duwamish area by 1985.

Value of Information: 5

Comments: None

LAND USE

Environmental Policy Advisory Committee. 1971. Interim Regional Development Plan. King County Department of Housing and Urban Planning Assistance Program, 1 Vol., 35 pp.

Source of Information: SAI Library

Area of Study: Puget Sound region

The Duwamish is shown as an urban and suburban area on the Land Use Plan Map of this document. There are policies on page 24 relating to the marine shoreline. Preservation and acquisition of tidelands for public use is recommended, improved pedestrian and vehicular access is recommended, publicly owned tideland should remain publically owned, subdivisions should include public use and access to tidelands and enforcement of tideland management regulations should be made more effective. There is no specific definition of tideland and the Duwamish nor any other water body is mentioned by name.

Value of Information: 2

Comments: None

King County 1964. The Comprehensive Plan for King County, Washington.
Planning Department, 204 pp. plus map.

Source of Information: SAI Library

Area of Study: King County

This document includes policies intended to guide development in King County. Included in the plan is an open space element including water bodies, watersheds, and fisheries. Policies regarding water areas can be found on p. 143 and 144 and primarily address the issue of the preservation of water areas for recreational uses.

The 1975 Supplement contains more detailed policies relating to shoreline use and development. This plan would have jurisdictional power over the Duwamish Waterway and adjacent land uses.

Value of Information: 5

Comments: None

King County. 1972 to present. King County Code.

Source of Information: Seattle Public Library

Area of Study: King County

The King County Code is a document comprising all general acts, orders, and resolutions of the King County Council. The purpose of the ordinances is to form a more just and orderly government, establish separate legislative and executive branches, insure responsibility and accountability, enable effective citizen participation, preserve a healthy environment, and secure the benefits of home rule and self government in accordance with the Washington State Constitution. The code is organized by subject matter under an expandable three-factor decimal numbering system, designed to facilitate supplementation without disturbing the numbers of existing provisions. The code contains provisions for parks and recreation, health and sanitation, solid waste, animals, roads and bridges, water and sewer systems, building construction standards, mobile homes, subdivisions, fire code, etc. Titles 20 through 46 concern planning, zoning, land uses, shoreline definitions, and building restrictions, housing and traffic ordinances. The King County code would give specific lot and building requirements and specific land uses based on the King County zoning code and shoreline management program.

Value of Information: 5

Comments: None

King County. 1975. The Comprehensive Plan for King County, Washington; Supplement. Land Use Management Division, Department of Community and Environmental Development. 120 pp.

Source of Information: SAI Library

Area of Study: King County

This supplement includes changes and additions to the 1964 King County Comprehensive Plan. The "Open Space Element" of the Comprehensive Plan is expanded upon in Ordinance 1096 and includes floodplains, marshes, bogs, swamps, lakes, rivers, streams, ponds, and adjacent lands, saltwater marinelands, shorelands, beaches, and related uplands and wildlife habitats. The County may restrict and/or coordinate activities on or near shoreland areas when a sensitive and important marine habitat exists.

Ordinance 1489, "Shoreline Access Policies," indicates when pedestrian easements should be provided along lakes, rivers, streams, ponds, and marinelands. It also indicates the provision to restrict access time, number of people, area or other restrictions in areas of spawning grounds, fragile habitat for aquatic life or possible hazard to pedestrian safety.

Ordinance 4365, "Sensitive Areas," adopted in June 1979, contains requirements for special studies to be completed when developments are proposed in areas with landslide hazards, seismic hazards, erosion hazards, and wetlands.

These ordinances would apply to the Duwamish River and adjacent land uses.

Value of Information: 5

Comments: None

King County. 1978. King County Shoreline Management Master Program (King County Ordinances No. 3688, 3689, and 3692). 3 Vol., 150 pp.

Source of Information: GRA Library

Area of Study: King County

The King County Shoreline Management Master Program consists of three volumes: Goals, Policies, and Objectives; Regulations and Procedures; and a Supplement. Goals, policies, and objectives are presented for land use elements such as shoreline use, economic developments, public access, conservation, recreation, historical/cultural, circulation and residential. In order to implement these goals, objectives, and policies, the shorelines of the state in King County have been divided into "environments"; urban, rural, conservancy, and natural. The Duwamish Waterway in King County has been designated mostly urban and partly rural. The urban classification includes areas of high-intensity land use including industrial, residential, commercial and recreational. It is designed to reflect a policy of increasing utilization and efficiency of urban areas, to promote a more intensive level of use through redevelopment of areas now under-utilized and to encourage multiple use of the shoreline if the major use is shoreline dependent. The rural environment includes areas of agricultural use, low-density residential areas, and areas which provide buffer zones and open space between predominantly urban areas. New developments in the rural environment should reflect the character of surrounding areas by limiting density, providing permanent open space and by maintaining adequate building setbacks. Specific shoreline use activities are identified and discussed, and general policies are presented. These use activities include ports and industries, commercial development, landfill, dredging, piers and moorages, and residential development. A glossary of shoreline terms is included, as are discussions of specific procedures, permits, applications, setbacks, variances, and conditional uses.

Value of Information: 5

Comments: None

LAND USE

King County. 1978a. King County Land Capacity Study: Vacant Lands Inventory. Department of Planning and Community Development 62 pages.

Source of Information: SAI Library

Area of Study: King County

This is an inventory of all vacant lands in King County, excluding the city of Seattle. Map No. 4 shows the lands surrounding the Duwamish River from approximately Roxbury Street on the north to State Highway 51d on the south, where the Duwamish turns into the Green River. The Green River is shown in Map No. 5. Also included in this document are maps of vacant, sewerred lands, vacant unconstrained lands, and a combination map of vacant, sewerred, and unconstrained lands. There is a map of each of these for the area adjacent to the Duwamish described above. The vacant land acreage figures for census tracts 263 and 264 which surround the Duwamish include the entire census tract and are, therefore, not an accurate estimate of the vacant acres adjacent to the Duwamish River.

Value of Information: 5

Comments: None

LAND USE

King County. 1978b. Sensitive Areas Map Folio and Erosion Hazard Supplement. Department of Planning and Community Development, pages 14 and 76.

Source of Information: SAI Library

Area of Study: King County

This publication defines in map form several environmentally sensitive areas of western King County as a prelude to the preparation of comprehensive plan policies and regulations as provided in King County Ordinance 3821, Section 2. This document shows the areas which may be potentially hazardous to development, including Seismic Hazard, Slide Hazard, 100-year Floodplain and Drainage Basin classification, Wetlands, Fish, Utility, and Shoreline Management Areas. Map Nos. 4 and 5 show the Duwamish and Green Rivers. The entire Puget Sound Basin is nationally classified Zone III (the most hazardous) due to its history of major earthquakes and associated damage. Within Puget Sound there are Class II and Class III seismic hazard areas based on soil types. The shoreline adjacent to the Duwamish and Green Rivers is designated as Class II and in some parts, Class III. The shorelines (mapped) have little to no slide and slippage hazards. The Duwamish River, from approximately Boeing Field south up to and including the Green River, is classified as the 100-year floodplain. The Duwamish and the Green Rivers are both classified as anadromous fish use rivers with 20 cfs mean annual flows or greater. There are no erosion hazards mapped along the Duwamish River.

Value of Information: 5

Comments: None

King County. 1979. Highline Communities Plan. Department of Planning and Community Development, 225 pages plus appendices.

Source of Information: SAI Library

Area of Study: South King County, Highline area

This community plan is intended to guide development in the Highline area and serve as an update to the existing King County Comprehensive Plan for this community. The planning area is west of the Duwamish River but is adjacent to the west bank of the river in several places. The primary land uses are low density residential.

Value of Information: 5

Comments: None

LAND USE

King County. 1979. Supply-Demand Study. King County Growth Management Program, '11 pages.

Source of Information: SAI Library

Area of Study: King County

This study looks at the issue of developable land supply in relation to demand for development over the 12-year period between now and 1990. The study is broken into two parts. Part one identifies where and in what land use categories there may be surpluses or deficits of vacant land within the next ten years. The second part examines land supplies in relation to the demand forecasts based on the Puget Sound Council of Governments household and employment forecasts for 1978. The findings will be used to provide background information for the new King County Comprehensive Plan, and will establish a basis for monitoring future development activity. The Green River is included as a subarea of analysis and the Duwamish is included within the Seattle subarea. There are generalized maps of each subarea which show the dwelling units per acre, the employees per acre, and the Capital Improvement Program (CIP) planning areas. The information is generalized for the entire subarea and, therefore, an analysis of the exact dwelling units or employees per acre that are adjacent to the Duwamish River could not be interpreted from these maps.

Value of Information: 4

Comments: None

LAND USE

King County, Green River Technical Committee. 1978. Draft Green River Basin Program. 113 pages plus Appendices 1, 2, 3, 4 of the Program.

Source of Information: King County Library

Area of Study: Green River Basin

This report represents a three part local action program through which King County and the Cities of Kent, Auburn, Renton, and Tukwila will investigate and resolve the remaining flooding and surface drainage problems in the Green River Basin. The program stresses an integrated planning strategy in formulating surface water solutions, addressing surface water problems on a basin-wide scale, a stronger role for local governments in surface water decision making, and the coordination of the activities of federal agencies. Part one describes the Green River Basin, the history of flood control, and issues which led to this program. Part two outlines the methodology and implementation of the program. Part three describes several early action measures intended to provide an immediate response to surface water and flood control while the interim program proceeds. This process will include mapping critical drainage areas (base maps of existing wetlands, surface drainage systems, existing water regulations) and then assimilating this information into a viable policy plan. Part four proposes a basin-wide surface water management program, intended to coordinate the numerous activities of federal, state, and local agencies through a single comprehensive plan.

Value of Information: 3

Comments: This document does not as yet contain much information about land use but the upcoming studies should be very useful in this regard.

Langloe, L. September 1946. Report on the Development of Industrial Sites in the Duwamish-Green River Valley. Seattle Planning Commission, 32 pp. plus maps.

Source of Information: GRA Library

Area of Study: Duwamish

This report covers the Duwamish Waterway from the Renton Junction to the south end of the waterway, about 7 miles in length. There are a series of land use maps which classify areas as suburban residential, urban, agriculture and unimproved, recreational, and proposed industrial sites. The plan points to initial sites but recommends that each locality decide on specific parcels to be designated for industrial development. Industrial site identification is based on proximity to existing population centers, safe location away from flood zones, and power availability.

Value of Information: 3

Comments: Discussion of industrial development opportunities, primarily south of Boeing Field. Maps do not include Seattle.

LAND USE

Municipality of Metropolitan Seattle (METRO). January 1978. Areawide Water Quality Plan. 111 pp. w/ appendices.

Source of Information: SAI Library

Area of Study: Cedar-Green River Basins

Value of Information: 1

Comments: Comments are included on land use and other regulations of the City of Seattle, King County, and other jurisdictions.

Naramore Bain Brady and Johanson. 1973. South Park Neighborhood Development Program Plan Proposal and Summary Report. City of Seattle Department of Community Development; 2 Vol., plan proposal, 100pp.; summary report, 25 pp.

Source of Information: GRA Library

Area of Study: South Park

This report contains development guidelines and planning recommendations for the improvement of the South Park community. The study area encompasses approximately one square mile of land area bounded by State Route 509 (First Avenue South) on the west, the river on a diagonal running southeast to northwest, and South 96th Street and the city limits on the south.

Existing conditions are presented for the community on planning, zoning, population, circulation, public services, environment, economics, housing, industrial firms, land use, and land use demands. A plan is recommended to achieve delineated community goals for land use, residential areas, retail and commercial uses, physical improvements and public services. An action program is proposed with priorities, policy implications, financing, and management. Zoning, performance standards, industrial development standards, standards administration, and citizen action programs are discussed as parts of the action program.

Value of Information: 5

Comments: None

LAND USE

Pacific Northwest River Basins Commission. 1970. Comprehensive Study of Water and Related Land Resources - Puget Sound and Adjacent Waters. Puget Sound Task Force. Appendix II, 120 pages; Appendix V, 450 pages; Appendix XIV, 500 pages.

Source of Information: GRA Library

Area of Study: Puget Sound area

Appendix II - Political and Legislative Environment. This appendix provides a short (usually one to two pages) description of all federal, state, and local agencies, political bodies, special districts, etc., which have an interest in water and related land resources in the Puget Sound area. Also included is a somewhat dated (1970) survey of existing water-related legislation.

Appendix V - Water-Related Land Resources. This appendix contains a 30 page description of the Green River Drainage Basin, which includes the Duwamish study area. Land use (circa 1966) is tabulated and mapped at various levels of detail. Highest level of detail is provided for forest and agriculture, outside study area.

Appendix XIV - Watershed Management. This appendix contains a 9 page report on the Green River Basin, describing land use, soils and land capability and future needs for watershed management. It contains little detailed information on the Duwamish study area.

Value of Information: 2

Comments: See also pages D-24 and E-8.

LAND USE

Port of Seattle. May 1962. Industrial Development, Duwamish Waterway. 31 pp.

Source of Information: GRA Library

Area of Study: Port Lands, Duwamish Waterway

Value of Information: 2

Comments: Proposed filling for Terminals 102, 106, 105, 107, 117, with
method to be used.

Port of Seattle. April 1966. A Conceptual Framework for the Physical Development of the Port of Seattle. Planning and Research Department, 81 pp.

Source of Information: Port of Seattle

Area of Study: Port of Seattle

This report attempts to evaluate the pressures being exerted on the public port and to develop alternative paths which could or should be taken to meet the inter-regional competition which exists between ports and shape its character, responsibility, and opportunity. Economic reasons determine the distribution of activities; however, profit motivation, fair competition, and national economic welfare will require maximum efficiency of the system. The report is based on that assumption and is divided into five parts: (1) a discussion of commodity distribution, (2) projected changes in the commodity distribution, (3) discussion of these changes to the development of port areas, (4) past and future development of Seattle port areas, (5) schematic proposal for the port areas to accommodate projected changes. There are three alternatives to port and waterway improvements which include a proposal to further dredge the Duwamish Waterway and extend barge navigation, establish rail connection to an intermediate barge terminal suggested for the Duwamish Waterway, and several other proposals which relate to the ultimate interconnection between air, rail, and water industries.

Value of Information: 3

Comments: Most of this report deals with commodity distributions on a conceptual level. A short discussion of goals for industrial development is included (e.g., emphasize water transportation-related industries).

LAND USE

Port of Seattle. 1967. Duwamish Waterway Channel Improvement Preliminary Study. Planning and Research Department, 27 pp. w/ appendices.

Source of Information: Port of Seattle Library

Area of Study: Duwamish Waterway

This is a preliminary study of deepening of the East and West Waterways and the Lower Duwamish which were believed necessary to future economic development in the Port District and to the well being of the people of King County. Three maps are included in the appendix, Exhibit A, 1) Lower Duwamish Industrial District Land Use Map, 2) Industries Map, and 3) General Plan Map. The text discusses supportive economic data for the improvements and dredging requirements. Land use policies are not discussed.

Value of Information: 4

Comments: None

Port of Seattle. Sea-Tac Communities Plan. King County, approximately
200-300 pp.

Source of Information: SAI Library

Area of Study: Sea-Tac community

The northeastern corner of this planning area borders a portion of the western bank of the Duwamish area. The land use of the area is predominantly single family residential. The plan designates this area as a reinforcement area which indicates that the land uses are to be maintained and supported in their existing use and character.

Value of Information: 2

Comments: None

LAND USE

River Basins Coordinating Committee (RIBCO). 1974a. Final Report, Urban Runoff and Basin Drainage Study Draft. METRO, U.S. Army Corps of Engineers, approximately 100 pages plus appendix.

Source of Information: King County Library

Area of Study: Cedar-Green River Basin

This is one of four studies prepared by RIBCO which deals with urban runoff and basin drainage of the Cedar-Green River Basins. The plan was developed based on existing drainage conditions, problem areas, and projected future population distribution patterns. The study includes a breakdown of land use distribution in selected regional out-basins by total acreage. Based on an analysis of several alternative plans, the study sets forth summary recommendations addressed to the elements of drainage, management, financial considerations, and facilities plans and needs. Four technical appendices are included as part of this study.

Value of Information: 4

Comments: None

River Basins Coordinating Committee (RIBCO). 1974b. Environmental Management for the Metropolitan Area, Part I Water Resources. METRO, 161 pages plus bibliography. Part I Appendices, 180 pages.

Source of Information: King County Library

Area of Study: Lake Washington and Green River Basins

This study summarizes and integrates the available knowledge concerning the Lake Washington and Green River Drainage Basins and integrates this information into a management plan based on projected population to meet the needs of water use in the future. The two main water uses are for the home (i.e. lawns, bathrooms, appliances, etc.) and for recreation. Part I discusses land use of both drainage basins in terms of total acreage figures for agriculture, urban and suburban development, inland water, forests, range, and rural. This land use distribution is expected to change only slightly by the year 2000.

The plan proposes 5 alternative conceptual plans for water management in the future. Each of these plans is examined briefly for their environmental impact. Then one plan is recommended for the future management program because of its low cost and the benefits it provides in comparison to the other alternatives. The study then recommends a management program whereby a coordinated effort could be made by the City of Seattle and King County to implement the water management plan.

The appendices are a series of reports done by various individuals and provide the background material for the report.

Value of Information: 3

Comments: None

LAND USE

River Basins Coordinating Committee (RIBCO). 1974c. Urban Runoff and Basin Drainage Study Appendices A, B, and C. U.S. Army Corps of Engineers.

Source of Information: King County Library

Study Area: Cedar-Green River Basins

This report is an appendix to the Urban Runoff and Basin Drainage Study. It contains general information on each of the regional drainage sub-basins within the Green and Cedar River Basins and specific descriptions of all alternative drainage plans considered, including costs and environmental assessments. The Urban Runoff and Basin Study comprises one part of four studies which make up an environmental management program for the Green and Cedar River Basins: Part I - Water Resources, Part II - Urban Drainage, Part III - Water Quality, and Part IV - Solid Waste. This report represents a comprehensive plan for meeting the existing and long-range urban drainage needs within the Green and Cedar River Basins. The study recommendations address drainage facilities, capital costs, methods of financing, and institutional arrangements for effective program management. The recommended plans are conceptual and are intended for use by local governments as a guide in the future planning of drainage systems. This published report is composed of three appendices: A - Regional Sub-Basin Plans, Volume I Cedar River Basin and Volume II Green River Basin; Appendix B - Urban Storm Drainage Simulation Models; and Appendix C - Storm Water Monitoring Program.

Value of Information: 4

Comments: It is a conceptual plan only, but discusses existing and projected land uses in Appendix A, Volume II, Green River Basin.

Seattle, City of. 1979. Industrial Area Background Report. Office of Policy Planning, Economic Development Administration, 74 pp. plus references.

Source of Information: GRA Library

Area of Study: City of Seattle

This report furnishes background information for preparation of industrial land use policies and direction for preparation of industrial land use policies. The studies began in 1978 and a set of business and industrial land use policies were circulated in the fourth quarter of 1979. The City Council will take action on these policies during the second quarter of 1980.

This study maps the industrial areas and zoning of those areas including the area along the Duwamish. The report also defines industrial zoning and types of permitted uses. This report includes a description of the Shorelines Management Zone and its jurisdiction over land uses on the shoreline.

The Duwamish is discussed in detail in terms of acres of industrial zoned land, types of land uses, detailed mapping of zoning and investment activity.

The last half of the report deals with tax revenues and employment and is not very relevant to the study.

Value of Information: 4

Comments: None

Seattle, City of. 1974. Proposed Comprehensive Policy Plan, Draft 1. Department of Community Development and Department of Human Resources, approx. 205 pp.

Source of Information: SAI Library

Area of Study: Seattle

This plan proposes policies based primarily on the Seattle 2000 report. One goal relating to water is that the City should undertake efforts to meet Federal Water Pollution Control Act P.L. 92-500 requirements by 1984. The policy relating to this goal is to encourage citizen awareness of water pollution problems (p. V-17). Wetlands, waterways, etc. are to be preserved and enhanced by planning, issuance of permits continuing performance standards and the zoning powers of the city. The City shall protect the existing beauty of all waterfronts, saltwater shores, and creeks by: implementing the Shoreline Management Program, prohibit construction of new utility poles, and prioritize shoreline improvements. These are general policies and they would relate to the Duwamish but the Duwamish is not mentioned by name in the document.

Value of Information: 3

Comments: None

Seattle, City of. 1976. Seattle Shoreline Master Program. Department of Community Development, 83 pp. plus map.

Source of Information: SAI Library

Area of Study: Seattle

This document is intended to guide land use and development decisions on Seattle's shorelines. The elements included in the plan are: economic development, public access, circulation, recreation, shoreline use, conservation, and historical/cultural elements. The plan identifies shorelines of statewide significance, including the Duwamish River wetlands associated with the river, to be regulated by this plan. The entire length of the river is designated urban development with the exception of Kellogg Island which is designated conservancy natural. The purpose of the urban development is to provide for efficient utilization of those areas suitable for water-dependent commerce and industry. There are no view corridor, lot coverage, or maximum height restrictions on the Duwamish River. The purpose of the conservancy natural environment is to preserve and restore natural systems and resources and prevention or regulation of uses or activities which would degrade the natural environment.

Value of Information: 5

Comments: None

LAND USE

Seattle, City of. August 1979. Proposed Reenactment of the Seattle Shoreline Master Program. Department of Community Development, 105 pp.

Source of Information: SAI Library

Area of Study: Seattle

The revisions to the existing Shorelines Plan are classified as either editorial, procedural, or substantive changes. Editing has been done for clarity and removal of confusing, redundant, or ambiguous language. The most significant substantive changes will:

- 1) Modify and clarify view corridor requirements;
- 2) Establish shoreline variance and conditional use permit procedures consistent with the Washington Administrative Code;
- 3) Allow upland lots to be developed with uses and bulk provisions of the zoning ordinance;
- 4) Require development of waterfront lots on Lake Union, Salmon Bay, and Portage Bay to be water-dependent;
- 5) Revise bulk and moorage requirements for floating homes;
- 6) Remove Central Waterfront Planned Unit Development provisions;
- 7) Require that lot coverage and density calculations for residential uses shall not include lands waterward of the ordinary high water mark.

Map changes affecting land uses include changing an area presently designated Conservancy Management (CM) to Urban Mixed (UM) located easterly of Harbor Avenue S.W. between S.W. Bronson Way and S.W. California Place. This change is geographically close to the western waterway, however, it probably would not impact the use of the Duwamish. The designation of lands adjacent the Duwamish have not changed from the original SMP.

Value of Information: 5

Comments: None

Seattle, City of. 1977, 1978, 1979. Seattle Municipal Code, Title 26, Zoning. Approx. 300 pp.

Source of Information: SAI Library

Area of Study: Seattle

The prevalent zoning along the Duwamish is IG, General Industrial and IH, Heavy Industrial. The IG permits all uses allowed in the Manufacturing zone plus other general industrial uses. Specific requirements include parking facilities for trucks and employees, screening around property lines. Lot coverages and minimum size are not required for industrial users. The Heavy Industrial zone permits those uses permitted in the IG zone and others. No minimum lot area is required. The gross floor area of any structure not including parking, shall not exceed 2½ times the area of the lot except with modifications noted in Sections 26.44.020 and 26.44.030 of the zoning code.

Value of Information: 5

Comments: None

LAND USE

Seattle, City of (pending publication). Economic Development Plan. Office of Policy and Evaluation. Preliminary Draft.

Source of Information: Department of Community Development

Area of Study: City of Seattle

Value of Information: 2

Comments: Industrial areas of the city are ranked third for priority of attention by the City of Seattle, after neighborhoods (#1) and downtown (#2).

Seattle 2000 Commission. 1973. Goals for Seattle 2000. City of Seattle, 391 pp.

Source of Information: SAI Library

Area of Study: Seattle

This document contains goals for various land use groups including: "The Comprehensive Plan should establish means to protect, preserve, and use to the best advantage, Seattle's heritage of natural assets: lakes, shorelines, streams, views, topography, trees, and natural vegetation" and "Seattle's industrial area should be improved and not be allowed to expand horizontally." The recommendations for shorelines and the industrial land uses, adjacent the Duwamish would apply to type of development and use of the river and waterfront. The goals are general in nature and the Duwamish is not specifically mentioned.

Value of Information: 3

Comments: None

LAND USE

Tukwila, City of. 1977. Comprehensive Land Use Policy Plan. Office of Community Development, Planning Division, 100 pages.

Source of Information: SAI Library

Area of Study: Tukwila

The Tukwila Comprehensive Policy Plan is intended to aid in the decision-making process of the City by identifying major problem areas, establishing community goals on growth and development, and providing staff with more direction in the everyday implementation of the City's laws and procedures. The Duwamish River is included on the land use maps, from about the intersection of Pacific Highway South and Highway 599 to where it becomes the Green River. The land uses adjacent to the Duwamish are primarily light industrial, low density residential, parks, and open space.

Value of Information: 5

Comments: None

LAND USE

Tukwila, City of. 1978. Land Use Survey. Tukwila Planning Department, approximately 12 pages.

Source of Information: SAI Library

Area of Study: City of Tukwila

This is a land use inventory of all the types of land uses within the city of Tukwila. An employment section is also included which breaks out employment into two types: wholesale distribution, and processing manufacturing. Lands adjacent to the Duwamish River which are within Tukwila's city limits are included in the survey.

Value of Information: 3

Comments: None

SURVEYS AND INVENTORIES

Christy, I. 1979. Harbor Area Planning Project: State of Washington
(includes an individual report on Seattle). Department of Natural
Resources, Olympia, Washington.

Source of Information: Department of Natural Resources - Rick Vining

Area of Study: Seattle, State Harbors

Value of Information: 2

Comments: A general synopsis of harbor use data for state and individual
areas, some cost data included.

LAND USE

Economic Development Council of Puget Sound. (not dated; latest information, 1974). Industrial Land Sales in Seattle and King County. 11 pp.

Source of Information: GRA Library

Area of Study: Duwamish area

Value of Information: 2

Comments: Numbers of sales showed steady increase (to 64 in 1974) but average size declined to approximately 39,000 sq. ft. from peak of 93,000 sq. ft. in 1967. Most (41%) of sales were \$1.01 to \$2.00 per square foot, a decrease from \$2-3 range of 1972 but consistent with earlier trends.

Gilley Company. 1979. Survey of the South Seattle Industrial Area of Seattle, Washington. 1 Vol., 29pp.

Source of Information: GRA Library

Area of Study: South Seattle Industrial area

This study is of the approximate 5,500 acre South Seattle Industrial Center. The area is bounded on the north by the Central Business District, on the west by West Marginal Way South, on the south by a plane between Interstate 5 and the Duwamish Waterway Turning Basin south of Boeing Field, and on the east by Interstate 5. The area is divided into 8 subareas; the Duwamish Waterway is the predominant physical feature. The survey includes zoning, vacant land by zone, land and lease prices, building prices, utility availability and other information specific to subareas.

Value of Information: 4

Comments: None

LAND USE

Hall, A.E., et al. (Management and Economics Research, Inc.) January 1968.
Shoreline Utilization in the Greater Seattle Area. National Council on
Marine Resources and Engineering Development, Executive Office of the
President, 1 Vol., 140 pp.

Source of Information: GRA Library

Area of Study: Everett to Tacoma; Duwamish is a subarea

Value of Information: 3

Comments: Old (1968), but specific uses by manufacturing type inventoried in
Duwamish area (categories of adjacent to water and 1 block from
water) uses by manufacturing type. Very specific industry type
(e.g., Hardware, marine craft, stone, clay, etc.).

LAND USE

Muckleshoot Indian Tribe. Report on Tribal Duwamish Riverfront Property. No date. Bureau of Indian Affairs, U.S. Department of Interior, 4 pp.

Source of Information: Bureau of Indian Affairs

Area of Study: Duwamish riverfront next to the First Avenue Bridge in downtown Seattle

This report outlines the past conflict between the Tribe and the City in terms of the previous buildings which occupied the Tribal property. The previous buildings were demolished in 1979 with the exception of one shed, in an effort to comply with the City's desires regarding the property. The Tribe has since decided that use of the property is to be for fishing and fish-related activities. The possible alternative future uses include: (1) a small boat marina, (2) a small boat marina service yard with haul-out facilities, and (3) a small fish/seafood processing plant or (4) a combination of any of these.

The report recommends an economic feasibility study of potential uses of the property prior to further action.

Value of Information: 4

Comments: None

Port of Seattle. Facilities Handbook. 53 pp.

Source of Information: Port of Seattle

Area of Study: Port of Seattle

Value of Information: 5

Comments: A small format handbook of photos and descriptions of all Port facilities, with a map/directory.

Seattle Area Industrial Council. Duwamish Basin Development Committee.
Chamber of Commerce, approx. 25 pp.

Source of Information: Port of Seattle Library

Area of Study: Duwamish Basin

This report examines development potential for the Lower Duwamish Basin. Included is a section on land use and availability in the Lower Duwamish Basin including acreage of land uses and general ownerships. Included is a preliminary report by DCD entitled, Costs and Benefits of South Park Redevelopment. Land use data and assessed valuations on two areas in South Park, along the waterway is included in this sub-report. This report is more of an inventory of existing acreages and land uses and not policies or a plan. The document, and therefore the data, is undated.

Value of Information: 3

Comments: None

LAND USE

Seattle, City of. October 1977. Vacant Industrial Land Survey. Office of Policy Planning, 16 pp.

Source of Information: GRA Library

Area of Study: Seattle, Duwamish as subarea

Vacant lands in three zones (M-Manufacturing; IG-General Industrial; and IH-Heavy Industrial) were surveyed in 1971 and again in 1977. Information is presented for four subareas within Seattle; the Duwamish Industrial area contained 73% of vacant industrial land. Various cross-tabulations of data are made between district, zoning, land use (vacant, under-utilized, or residential), acreage, number of sites, size distribution of sites, topographic conditions, and transportation access to sites.

Value of Information: 4

Comments: None

LAND USE

Thompson, O., L. Erickson, J. McDaniel, D. McKay, and M. Augrigemma. June 1978. Results of the Block-by-Block Survey of Seattle to Identify Vacant Structures. Seattle Building Department, Housing Conservation Division. 9 pages plus appendices.

Source of Information: GRA Library

Area of Study: Seattle

Value of Information: 1

Comments: This survey identifies the number of vacant buildings per census tract for Seattle but does not identify the location of the buildings.

LAND USE

U.S. Army Corps of Engineers. 1976. The Port of Seattle, Washington.
The Board of Engineers for Rivers and Harbors, 122 pages plus maps.

Source of Information: Port of Seattle Library

Area of Study: Duwamish

Value of Information: 4

Comments: This lists port and harbor conditions in terms of depths of Duwamish Waterway, piers, wharves, and docks. It lists exactly what each pier is used for including location, owner, operator, dimensions, depth, load capacity, mechanical handling facilities, floor area for cargo, railway connections, highway connections, water and electric supply, and fire protection.

ENVIRONMENTAL AND ARCHAEOLOGICAL ASSESSMENTS

Benson, C.L. (Office of Public Archaeology Institute for Environmental Studies, University of Washington). February 1978. Archaeological Assessment of Kellogg Island, King County, Washington. Port of Seattle, Reconnaissance Report No. 20, 17 pages.

Source of Information: Northwest Collection, Suzallo Library, University of Washington

Area of Study: Kellogg Island

On recommendation by the Port of Seattle and the City of Seattle's Landmarks Preservation Board resulting from test excavations at the Duwamish No. 1 site located on the Port's Terminal 107 property, an archaeological assessment was made of Kellogg Island, also part of the Terminal 107 area, in August of 1977 by the Office of Public Archaeology. No significant prehistoric or historic resources were identified in the course of the field work. It is expected that any extant cultural remains on the Island are buried under the dredge spoils deposited there in the recent past, and it is recommended that a qualified professional archaeologist monitor any further development/use of the property necessitating removal of dredge spoils and fill material.

The report contains natural and cultural histories of both the Duwamish Basin and Kellogg Island.

Value of Information: 3

Comments: No information is given on aquatic life or wildlife. Also, see pages D-18 and D-20.

King County. March 1974. South Area Park and Athletic Facility, Draft Environmental Impact Statement. Architecture Division, Department of Community and Environmental Development.

Source of Information: GRA Library

Area of Study: South Area Park (South Center)

This EIS discusses the impacts of construction of the South Area Park and Athletic Facility. The Land Use Section covers existing uses adjacent to the river and impacts the proposed project would have on adjacent land uses. The Relationship to Existing Laws and Plans covers permits required, Tukwila Comprehensive Plan, PSCOG, Interim Regional Development Plan, Washington State Shoreline Management Act of 1971, and Washington State Comprehensive Outdoor Recreation and Open Space Plan. All are covered briefly and no analysis of policies is made.

Value of Information: 2

Comments: None

Lorenz, T.H., G.R. Spearman, and J.V. Jermann. May 1976. Archaeological Testing at the Duwamish No. 1 Site, King County, Washington. University of Washington, Office of Public Archaeology, Institute for Environmental Studies, 70 pp.

Source of Information: Pacific Northwest Collections, University of Washington Libraries

Area of Study: Vicinity of Kellogg Island

Value of Information: 1

Comments: Report presents results of an archaeological investigation of the site relative to the proposed Terminal 107 Barge Facility Development by the Port of Seattle.

LAND USE

Port of Seattle. January 1973. Dredge Spoil Disposal - Kellogg Island, EIS.
5 pp.

Source of Information: Port of Seattle

Area of Study: Kellogg Island

Value of Information: 1

Comments: Brief EIS for disposal of 180,000 cubic yards of spoil on 7.5 acres
in the southern end of Kellogg Island.

Port of Seattle. June 1975. Pier 2 - Railway Transfer Ramp Expansion Project, EIS. 25 pp. w/ appendices.

Source of Information: GRA Library

Area of Study: Shoreline of Elliott Bay, west of West Waterway

Final Environmental Impact Statement for a 45,000 cubic yard fill at Pier 2, Port of Seattle. The fill would provide for the expansion of the capacity of an existing facility for the transfer of rail cars between the Burlington Northern tracks and the Alaska Hydro-Train barges. The project is found consistent with City of Seattle Zoning and Shorelines Management designations.

Value of Information: 3

Comments: See also page E-9.

Port of Seattle. April 1976. Southeast Harbor Area; Environmental Studies and Assessments of Impacts of Possible Developments. 200 pp. w/ references.

Source of Information: GRA Library

Area of Study: Southeast Harbor Development, Port of Seattle

Seven reports by consultants to the Port of Seattle comprise this volume covering the Southeast Harbor Area, from Pier 48 nearly to the Spokane Street Bridge. The consultants are: Sediments-CH2M Hill; Current Regime-CH2M Hill; Water Quality-Meloy Malkoff; Marine Life-Parametrix, Inc.; Noise-Hugh J. Parry Noise Consulting; Traffic-JWM and Associates; and Air Quality-Alsia, Snowden and Associates.

Of these seven reports, the one which includes land use information is Traffic, by JWM and Associates. The predominant land uses, population, and employment are discussed in a very general way, as background information for existing traffic conditions. The existing transit and road systems are also discussed and mapped in this report.

Value of Information: 2

Comments: See also page D-25.

Port of Seattle. Draft, April 1976; Final, August 1976. Proposed Terminal 37 Expansion Project - Southeast Harbor Area, Draft/Final EIS. Each 1 Vol. with appendices and references.

Source of Information: GRA Library

Area of Study: Terminal 37, Port of Seattle

Environmental Impact Statement for Phase I of Port of Seattle's Southeast Harbor Development. This proposed action involves filling of 23 acres, now open or covered water, and associated paving and construction, for a Roll-on-Roll-off Terminal. Includes discussions of laws and plans, with some detail on Seattle Shoreline Master Program (Appendix C). Other relevant sections include future development alternatives for the Southeast Harbor Area, and appendices (F) a Characterization of Port Terminals and Other Properties in the Southeast Harbor Area; (H) Port Costs and Future Needs in Relation to the Shipping Industry; and (D) Generalized Analyses and Explanations of Cargo Flows through Seattle's Southeast Harbor.

Value of Information: 5

Comments: None

LAND USE

Port of Seattle. Draft, May 1977; Final, August 1977. Proposed Terminal 46 Expansion Project - Southeast Harbor Area, EIS. 2 Vol. with appendices and bibliographies.

Source of Information: GRA Library

Area of Study: Terminal 46, Port of Seattle

Value of Information: 4

Comments: See Terminal 37 EIS. This is Phase III of Southeast Harbor area; 18 acre fill and associated construction, north of Terminal 37.

Port of Seattle. Draft, May 1978; Final, September 1978. Proposed Terminal 30 Project, Southeast Harbor Area, EIS. 2 Vol. with appendices and bibliographies.

Source of Information: GRA Library

Area of Study: Terminal 30, Port of Seattle

Value of Information: 4

Comments: See Terminal 37 EIS. This EIS is south of Terminal 37 and is Phase IV of Southeast Harbor project, and includes less than 13 acres of fill and associated construction.

Port of Seattle. 1978. Final Report on Definition of Alternative Forms of Development for Terminal 107 (Kellogg Island and vicinity). Planning and Research Department.

Source of Information: Port of Seattle Library

Area of Study: Kellogg Island

The purpose of the report is to provide a common set of assumptions for assessing the relative impacts on the human and physical environment of the development which might be proposed for the study area. The report discusses alternative forms of development in detail and discusses land use in terms of archaeological potential, vegetation, and ownership and type of land which would be affected by development alternatives.

Value of Information: 2

Comments: None

Seattle, City of. 1976. Commercial Wharf Development, Chiyoda Chemical Engineering and Construction Co., Ltd., Final EIS. Department of Community Development, 50 pp.

Source of Information: GRA Library

Area of Study: Duwamish Waterway, east bank

The Final EIS for initial site development including the dredging of 80,000 cubic yards of material to be used to level the upland portions of the site, and construction of a 70 by 150 foot open pile wharf, a 2,000 square foot office building and a 200,000 square foot warehouse. Project is on east bank of Duwamish Waterway about 3,000 feet south of the Spokane Street Bridge, across from Kellogg Island.

Value of Information: 2

Comments: See also page E-11.

Seattle, City of. 1979. Proposed Reenactment of the Seattle Shoreline Master Program, Draft Supplementary EIS. Department of Community Development; Washington State Department of Ecology. 63 pp.

Source of Information: SAI Library

Area of Study: Seattle

This document discusses the impacts to land use, zoning, aesthetics and economics under the reenactment of the Shorelines Master Program. The impacts would be greatest to the C-G zones which are not found along the Duwamish River. The text indicates that much permit activity has occurred in the vicinity of Harbor Island and the Duwamish River. The impacts of the reenactment would primarily effect Portage Bay, Salmon Bay, and Lake Union, and not the Duwamish.

Value of Information: 2

Comments: None

Seattle, City of. Draft, June 11, 1979; Final, September 4, 1979. South Park-Duwamish Annexation, Draft and Final EIS. Department of Community Development and URS, DEIS, 62pp. w/ appendices; FEIS, 99 pp. w/ appendices.

Source of Information: GRA Library

Area of Study: South Park-Duwamish

This Draft EIS addresses the impacts of the annexation of a 920 acre area adjoining the southern boundaries of the City of Seattle. The impacts are primarily addressed in terms of financial impacts and impacts on services. The land uses would essentially remain the same but due to the differences in zoning classifications minor changes would occur. For example, the County has more restrictive setback requirements in shoreline areas, than the City, however, the County permits a larger variety of uses in their urban designation than does the City in their urban development designation. These types of changes are discussed in a general way in four subsections of the Land Use Section entitled, Land Use, Zoning Shoreline, Shoreline Plans and Comprehensive Plans.

Appendix C includes a comparison of City and County Building Codes and fees. It outlines the changes in building setbacks, and uses permitted that would occur if the annexation were to occur.

The Final EIS has an expanded Land Use Section, in particular the impacts section which covers changes in costs for services and utilities and incorporates specific issues, such as sewer lines, of concern after the Draft EIS was written.

Value of Information: 4

Comments: None

Seattle, City of. September 1979. Sewage Collection System Modifications (201 Facility Plan Implementation Program), Draft EIS. Engineering Department, 146 pp. w/ appendices and references.

Source of Information: GRA Library

Area of Study: Seattle Waterways

This Draft EIS analyzes the beneficial and adverse effects which may be expected to result from a proposed program of modifications to the City of Seattle collector sewer network. The objective of the program is to reduce discharges of untreated sewage into public waters. The EIS covers the legislation and the planning process including: the Draft Facility Plan for Upgrading Metro Puget Sound Plants, System-Wide Volume Part I, Summary of the Fourth Annual Report of the Council on Environmental Quality (September 1973), Duwamish 201 Facility Configuration and Metro CSO Control Program, December 1978.

A summary of the water quality of the Duwamish is included in the EIS and a brief summary of fish species of the river, and impacts that the sewage modifications will have on both.

Value of Information: 4

Comments: None

LAND USE

Team Research and Engineering. June 1979. Seaking Industrial Park, EIS.
King County, 2 Vol. Draft, 50 pp. w/ appendices; Final. 50 pp. w/ appendices.

Source of Information: King County Building and Land Development

Area of Study: West bank of Duwamish River; at 14th Avenue South and South
93rd Street

Value of Information: 4

Comments: EIS on proposed 24 acre industrial park - no use within 200 feet of
Duwamish, rest of site - 450,000 square feet of buildings proposed.

LAND USE

The Transpo Group. September 1976. Lucile Street Bridge Feasibility Study for the City of Seattle and Burlington Northern and Union Pacific Railroads. City of Seattle, Burlington Northern, Union Pacific. 42 pages and Errata Sheet.

Source of Information: GRA Library

Area of Study: Between Georgetown and West Beacon Hill/Lucile Street Bridge

This EIS analyzes four alternatives to the proposed Lucile Street Bridge Facility. The EIS covers land uses, community facilities, daily traffic volumes, accidents, benefit cost ratio of alternatives compared to bridge removal, and utility/cost analysis of community impacts.

The Existing Conditions section covers population, zoning, and land uses of the surrounding communities. The study does not include a recommended alternative but rather analyzes the alternatives in a factual manner.

Value of Information: 2

Comments: No policies are mentioned here.

LAND USE

U.S. Army Corps of Engineers, Seattle District. 1979. Final Supplement to Environmental Statement, Seattle Harbor Navigation Project Operation and Maintenance. 12 pages with appendices and bibliography.

Source of Information: SAI Library

Area of Study: Seattle Harbor/Duwamish Area

This proposed project is the continued maintenance dredging of the Seattle Harbor Navigation Project, King County, Washington. This document includes discussion of land use and facilities along the waterway, and of the relationship of the proposed project to existing land use and shorelines management plans.

Value of Information: 3

Comments: None

U.S. Maritime Administration Studies. March 1975. Port System Study for Public Ports of Washington State and Portland, Oregon. U.S. Department of Commerce, National Technical Information Service. Volume I, 37 pp. plus technical supplements, Volume II, parts 1-6.

Source of Information: GRA Library

Area of Study: Puget Sound region and Oregon region

This document examines the actions required to maintain a system of maritime ports capable of meeting future requirements of foreign and domestic trade. The study forecasts waterborne commerce and changes in cargo and handling technologies to the year 2000. The study then translates these anticipated changes into port facility needs and financial requirements over the same period. Finally, the study recommends an organization approach for coordinating future port developments, thereby ensuring the most effective use of public funds.

The study is intended to serve as a comprehensive base for cooperative regional port planning and development activities.

The principal subdivisions of the work program report in the Technical Supplement are:

- Part 1: "Study Approach, Commodity Specifications, Trend Analysis, and Domestic Trade Origin and Destination Data" by the Aerospace Corporation
- Part 2: "Port Facilities Inventory" by Reid, Middleton & Associates, Inc.
- Part 3: "Forest Products Analysis" by Greenacres Consulting Corporation
- Part 4: "Puget Sound and Lower Columbia Subregion Commodity Forecasts" by Engineering Management Sciences Corporation
- Part 5: "Marine - Port Technology Forecasts and Demand Analyses" by Frank J. Nickels, Naval Architect
- Part 6: "Port Capacity Analyses and Methodology" by Reid, Middleton & Associates, Inc.

Part 2 (Port Facilities Inventory) discusses each of the ports of Puget Sound in detail. Terminal 37 at the entrance to the east waterway and the Duwamish is included in this inventory of existing facilities on pages 2-9 through 2-10.

The other technical appendices contain the background information that led to the recommended future facilities development plan.

Value of Information: 3

Comments: None

LAND USE

U.S. Maritime Administration Studies. Draft 1979 Update of Port System's Study for Public Ports of Washington State and Portland, Oregon. U.S. Department of Commerce, National Technical Information Service.

Source of Information: Port of Seattle

Area of Study: Puget Sound region and Oregon region

Value of Information: Unknown

Comments: This document will not be available until December 1980.

LAND USE

University of Washington, Office of Public Archaeology. March 1977.
Continued Archaeological Testing at the Duwamish No. 1 Site (45 K 123).
Port of Seattle, 103 pages.

Source of Information: Port of Seattle

Area of Study: Kellogg Island, Terminal 107

Value of Information: 2

Comments: Very localized history and existing land use information.

Washington State Department of Highways. 1972. Environmental Statement
SR 99 Duwamish River Crossing. Federal Highway Administration, 46
pages.

Source of Information: Port of Seattle Library

Area of Study: Duwamish River Crossing

This is a draft impact statement for construction of a 5-lane bascule bridge clearing a 200-foot wide waterway channel with a 14-foot vertical clearance across the Duwamish Waterway at First Avenue South in Seattle, Washington. There is an existing land use map, and an existing zoning and public facilities map. The section on Land Use on pages 14-17 discusses existing land use and zoning in a strip along the Duwamish. This study indicates that 97% of Seattle's heavy industrial zoning is located in the Duwamish Valley and over 70% of the city's general industrial zoning. Other land uses are discussed in a general way. The impacts of the proposal are discussed on pages 29-30 in a general way. The maps appear to be very good, although they are bound to be somewhat out of date.

Value of Information: 4

Comments: None

OTHER

LAND USE

Battelle Northwest Laboratory. January 1966. An Economic Evaluation of the Potential for an Upper Duwamish Bargeway. Port of Seattle, Richland, Washington, 1 Vol., 70 pp. w/ appendices.

Source of Information: Port of Seattle

Area of Study: Duwamish

Value of Information: 3

Comments: An economic evaluation of extending the Duwamish Bargeway an additional 5 miles to a point southwest of the City of Renton. Includes discussion/projection of shipping; industry and land use.

LAND USE

Bohman, B. April 1976. Bibliography - Publications of the Port of Seattle.
Planning and Research Department, 1958-1976. Port of Seattle, 1 Vol.,
14 pp.

Source of Information: GRA Library

Area of Study: Port of Seattle

Value of Information: 3

Comments: Includes bibliography from Sea-Tac Communities Plan as appendix.

Cleveland High School. 1949. Duwamish Diary. 1 Vol., 120 pp. w/ bibliography.

Source of Information: GRA Library

Area of Study: South Park, Duwamish area

Value of Information: 2

Comments: History of Duwamish River to 1949.

Duiker, G. July 1979. Survey and Review of Fiscal Matters Related to the Proposed South Park/Duwamish Annexation by Seattle. King County Department of Budget and Program Development, 1 Vol., 54 pp. w/ bibliography.

Source of Information: GRA Library

Area of Study: South Park, Duwamish area

Value of Information: 2

Comments: Analyzes proposed annexation by Seattle. Projects a loss of \$128,000 for King County taxpayers if small area is annexed and a net gain of \$302,000 if a larger area (including White Center) is annexed. In both cases, however, severe reductions in revenue by some Special Taxing Districts such as Fire District #1.

Falchi, P. 1977. Intra-Urban Industrial Location Changes in the Seattle Area: 1960-1970. M.U.P. Thesis. University of Washington, Department of Urban Planning, 82 pp.

Source of Information: University of Washington Archasology and Urban Library (Gould Hall)

Area of Study: City of Seattle

This thesis discusses the theory of intra-urban industrial location with reference to centralization and decentralization. The industrial changes within Seattle from 1961-1970, based on building permit statistics, are discussed with their relationship to this theory. There are maps documenting the areas and numbers of permits issued and employment characteristics. There is a section which discusses industrial land use changes with tables documenting acreages of manufacturing land use by AAM Districts from 1961 through 1970. The document is useful in delineating the changes in manufacturing land uses between 1961-1970.

Value of Information: 3

Comments: None

Governmental Research Assistance Library.

Area of Study: Duwamish Basin

The library maintains an extensive vertical file system. Holdings pertinent to this study include Industrial Development and Waterfront files to Seattle and King County. The files contain clippings, small reports, and pamphlets.

LAND USE

Ljungren, V.L., Chief Engineer. May 1973. Duwamish Study for Widening and Deepening the Duwamish Channel. Port of Seattle Engineering Department, 9 pp.

Source of Information: GRA Library

Area of Study: Duwamish - West Waterway Terminus to First Avenue S. Bridge

Value of Information: 1

Comments: Proposes 250 foot wide by 40 foot deep channel and alignment to minimize impact on industries and amount of land to be acquired.

LAND USE

Math Sciences Northwest. January 1973. An Initial Reconnaissance for the Duwamish Industrial Area - Analysis of Economic Incentives for Using Combined Process Waste Treatment Systems for Selected Industries. Seattle, King County Economic Development Council, 27 pp. plus appendices.

Source of Information: GRA Library

Area of Study: Duwamish Industrial Area

Value of Information: 1

Comments: Economics and feasibility for combined waste water processing for manufacturing likely in Duwamish.

Seattle City Council. 1970. Historical Development of Interest and Information leading to Identification of Duwamish Basin Planning Needs. 70 pp.

Source of Information: GRA Library

Area of Study: Duwamish Basin

This report provides information relating to preparations by the City of Seattle for participation in the joint City, Port, County application to the U.S. Economic Development Administration. Submitted via the Seattle, King County Economic Development Council, the proposal was funded and resulted in A Development Concept for the Duwamish Basin, February 1971.

Value of Information: 2

Comments: None

LAND USE

Seattle, City of. 1966. Preliminary Report on Land Use Goals, Principles and Standards. Planning Commission.

Source of Information: Port of Seattle Library

Area of Study: City of Seattle

Value of Information: 1

Comments: This document summarizes the goals used in establishing the comprehensive plan. It includes industrial land policies and goals on page 24-28 but does not specifically mention the Duwamish Industrial area.

LAND USE

Seattle, City of. October 1974. Position Statement and Analysis on Duwamish Annexation Proposal of City of Tukwila. Joint publication: City of Seattle, Port of Seattle, King County, 50 pp. w/ 40 pp. appendices.

Source of Information: GRA Library

Area of Study: Duwamish Basin

This document analyzes the Tukwila proposal for annexation of portions of the Duwamish Basin. A major focus is on intergovernmental cooperation and planning between the Port, Seattle, and King County. Major reports and plans resulting from this cooperation are discussed in detail, with an analysis of development progress toward these goals. Land use and various communities within the area are discussed.

Value of Information: 5

Comments: None

LAND USE

Seattle, City of. August 1977. Plan for the Disposal of Dredged Material on Upland Sites. Department of Community Development, Environmental Management Division; CZM Section 306 grant. 34 pp.

Source of Information: GRA Library

Area of Study: General, City of Seattle

Discusses background of dredge material disposal, agencies currently involved, and past and present disposal policies. Availability and size requirements for upland disposal within Seattle, discussion of alternative means of disposal, and Seattle General Policies and proposed (1976) regulations are included, with 22 entry bibliography.

Value of Information: 2

Comments: None

Seattle, City of. January 1980. West Seattle Bridge Replacement Location and Design Report. Engineering Department; West Seattle Bridge Design Team, 175 pp. w/ appendices.

Source of Information: GRA Library

Area of Study: Spokane Street Bridge (West Waterway)

Because of damage inflicted upon the existing West Waterway crossing of the Duwamish River at Spokane Street, a new high level, fixed crossing is to be constructed, connecting the existing Spokane Street viaducts in South Seattle, with local access to Harbor Island. Repair of the existing structure for other than temporary local access is not feasible due to the deteriorated condition of the existing structures and the high accident rate.

This report examined various alternatives for the main bridge crossing and the approach structures, with the intent of recommending three alternative structural systems for each of the two main portions of the bridge. In addition, the roadway geometrics, foundations, right-of-way, temporary facilities, and the other supporting elements of the design were also studied, with recommendations as to the most cost effective solution to each problem.

Value of Information: 5

Comments: None

LAND USE

Seattle-King County Economic Development Council. 1971. Development Potential for the Lower Duwamish Basin. 17 pp.

Source of Information: GRA Library

Area of Study: Lower Duwamish Basin

This report summarizes some constraints on Port and shipping growth in Duwamish Waterway area, such as bridge capacities and navigation channel size, and presents some basic ideas for a strategy to overcome these constraints. The proposed strategy includes prioritizing the Spokane Street Bridge and forming a long range program for land use reorganization in the Duwamish area.

Value of Information: 3

Comments: None

Seattle-King County Economic Development Council. 1971. Proposal to the Economic Development Administration for Funds to Create an Evaluation and Development Plan Covering the Duwamish Basin. 45 pp.

Source of Information: GRA Library

Area of Study: Duwamish Basin

Value of Information: 4

Comments: This proposal provides a rationale and justification, including some historical data. It was granted and resulted in A Development Concept for the Duwamish Basin, February 1974.

LAND USE

Seattle Urban Design Associates, HNTB, and Erickson/Masey. 1971. West Seattle Freeway Design Report, 36th Avenue S.W. to Interstate 5. City of Seattle, 105 pp.

Source of Information: Port of Seattle Library

Area of Study: West Seattle Freeway

This is a study seeking the comprehensive design of an upgraded transportation facility along the existing Spokane Street corridor. A zoning map is included on page 20 and a land use map on page 18, Duwamish Valley Waterway land use map on page 19, and land use of Harbor Island, a shipping facilities map and a parks greenbelt and open space map. The document also illustrates circulation systems. The remainder of the document covers the project goals and objectives.

Value of Information: 4

Comments: None

LAND USE

Thomas, B.P., and W.F. Winters. 1965. Comprehensive Plan for Flood Control. King County Flood Control Division. 66 pages plus tables and maps.

Source of Information: SAI Library

Area of Study: King County.

The Duwamish River does not have any designated flood zones; however, flood zones are identified south on the river where it becomes the Green River. Inundation of valley lands by backwater up a tributary occur in the old Black River Sub-basin. The flood control plan includes three alternatives to relieve this inundation problem. The first is to construct flood gates and a pump station at the mouth of the Black River to drain all local flood waters at all stages of the Duwamish. A second plan would enlarge and partially shorten the Duwamish downstream from Black River so it can carry the designed release from Howard Hanson Dam plus all inflow downstream therefrom and not create a flooding backwater condition in the Black River sub-basin. The final is the Soil Conservation Service (SCS) project which is a series of collection systems along the lines of natural drainage.

The plan recommends adoption of the SCS project and construction of gates and pumps at the mouth of the Black River to mitigate the flooding problems.

Value of Information: 3

Comments: None

LAND USE

Tippetts-Abbett-McCarthy-Stratton, Inc. 1957. Economic Justification - Proposed Duwamish Waterway Extension. Port of Seattle, 27 pages plus appendices.

Source of Information: Port of Seattle Library

Area of Study: Duwamish Valley

Value of Information: 1

Comments: This report covers the costs and benefits of a proposed channel improvement along the Duwamish Waterway. Included is a brief description of existing land and water transportation facilities and then detailed cost analysis of the project.

LAND USE

Tippetts-Abbett-McCarthy-Stratton, Inc. May 1959. Proposed Interstate Highway Crossing over Duwamish Waterway Extension. Port of Seattle, 20 pages.

Source of Information: Port of Seattle

Area of Study: Duwamish Waterway

Value of Information: 1

Comments: Proposed crossing by Interstate Seattle-Tacoma Highway, some discussion of land use, barge traffic, etc. Primary emphasis is to determine vertical clearance necessary.

LAND USE

Washington State Department of Highways, Social Economic Section. 1976.
Review Draft, Economic Analysis of Duwamish Waterway and Spokane Street
Bridge Alternatives. 55 pages.

Source of Information: Port of Seattle Library

Area of Study: Spokane Street Bridge Alternates

Value of Information: 1

Comments: The purpose of this report is to assist in identifying state-
wide economic interest that the proposed West Seattle Freeway
improvement may generate.

B. WATER QUALITY

I WATER QUALITY SUMMARY

Information on water quality is listed in four sections titled General Conditions, Dredging/Disposal and Fill Studies, Point Source Studies and Accidental Spills. Of note in General Conditions is the report Effect of Dredging on Water Quality and Sediment Transport in the Duwamish Estuary (STR, 1972). This study examined salt water intrusion sediment loading and effects on water quality.

The most significant information relating to dredging and disposal practices is found in the series of appendices Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site Puget Sound, Washington (U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. 1977). Each appendix is cited under the respective author (Appendix B: Stout and Lewis; Appendix C, Teeny and Hall; Appendix D, Volume I: Baumgartner et al.; Appendix D, Volume II: Sugai et al.; Appendix E: Pavlou et al.; Evaluative Summary: Tatem and Johnson). Of further interest is Release of Polychlorinated Biphenyls (PCB) in a Salt-wedge Estuary as Induced by Dredging of Contaminated Sediment (Hafferty et al., 1977). Two papers of special mention in the Point Source Studies section are Duwamish River Intensive Water Quality Survey (WDOE, 1980), and The Impact of Effluent from the Renton Wastewater Treatment Plant on the Dissolved Oxygen Regime of the Lower Green-Duwamish River (Yake, 1980).

The most definitive work on accidental spills in the Green-Duwamish River has been the study related to the PCB spill in 1974, Monitoring of Trace Constituents During PCB Recovery Dredging Operations; Duwamish Waterway (Blazevich et al., 1977).

II WATER QUALITY INFORMATION SOURCES

<u>Agency</u>	<u>Telephone Contact</u>	<u>Written Response</u>	<u>Personnel Visit</u>
Federal:			
US Environmental Protection Agency	Yes	Yes	Yes
US Geological Survey	Yes	Yes	Yes
US Army Corps of Engineers	Yes	Yes	Yes
Bureau of Indian Affairs	Yes	No	No
US Coast Guard	Yes	Yes	Yes
National Oceanic and Atmospheric Administration	Yes	No	Yes
State:			
Department of Ecology	Yes	Yes	No
Department of Social and Health Services	Yes	No	No
Local:			
City of Seattle	Yes	No	No
Seattle City Light	Yes	No	No
Port of Seattle	Yes	Yes	Yes
Municipality of Metropolitan Seattle	Yes	Yes	Yes
Oceanographic Institute of Washington	Yes	No	No
Muckleshoot Indian Tribe	Yes	Yes	Yes
University of Washington:			
Department of Oceanography	Yes	Yes	Yes
Department of Civil Engineering (Air and Water Resources)	Yes	Yes	No
Harris Hydraulics Laboratory	Yes	No	Yes
Libraries:			
University of Washington	No	No	Yes
Port of Seattle	No	No	Yes
Municipality of Metropolitan Seattle	Yes	Yes	Yes
US Geological Survey	Yes	No	Yes

<u>Agency</u>	<u>Telephone Contact</u>	<u>Written Response</u>	<u>Personnel Visit</u>
US Environmental Protection Agency	Yes	No	Yes
Department of Ecology	Yes	Yes	No

III General Conditions

Bowmann, B. April 1976. Publications of the Port of Seattle
Planning and Research Department 1958-1976. 15 pp.

Source of Information: Seattle Municipal GRA Library

Area of Study: Elliott Bay

The bibliography contains publications, including EIS's
listed by year. Several of the EIS's relate to pier and terminal
projects in the study area.

Value of Information: 3

Comments: None

WATER QUALITY

Dawson, W. A. and L. J. Tilley. 1972. Measurement of salt-wedge excursion distance in the Duwamish River Estuary, Seattle, Washington by means of the dissolved-oxygen gradient. U.S. Geological Survey Water-Supply Paper. 1873-d. Prepared in cooperation with the Municipality of Metropolitan Seattle, 27 pp.

Source of Information: Municipality of Metropolitan Seattle Library

Area of Study: Duwamish River Estuary

The Duwamish River estuary has been the object of a series of comprehensive studies undertaken to predict the effects of the changing character of waste-water inputs on the water quality of the estuary. This report discusses the fresh- and salt-water relations of the estuary. The distance that the salt-water wedge in the estuary moves upstream and downstream with the tide is measured by a method that utilizes the persistence of the longitudinal gradient of dissolved oxygen in the salt water of the wedges. The method, though unorthodox, can serve as an independent check on any other measurements of tidal-excursion distance. Typical values obtained were a 1-kilometer excursion for a 1.3-meter tide range and a 3-kilometer excursion for a 3-meter tide range. This method of tracing the water movement seems to work because of two unusual aspects of the Duwamish River estuary: (1) the channel configuration is simple and well-suited to synoptic measurement and (2) the physical properties of the entering salt water are nearly constant.

An extension of the present navigation channel farther upstream would also lengthen the salt wedge. Conceivably, an increased wedge length could result in an increase in wedge-water erosion rate and entrainment of salt water by the upper-layer water, and the increased entrainment might produce some benefit by increasing the dilution of any pollutants in the upper layer. On the other hand, a lengthened salt wedge would mean increased travel time of the wedge water to the upstream end and would thereby give oxygen-consuming processes more time to act. In this manner, the apparently unrelated action of dredging would cause a local degradation of water quality that would decrease the ability of the estuary to assimilate wastes and support fish life.

Thus the results of upsetting the delicate balance by arbitrarily altering the estuary can be beneficial or detrimental. Before prediction of all the imbalances and their ultimate consequences is possible, however, hydrodynamic analysis of the estuary must progress considerably beyond the present state of knowledge.

Value of Information: 4

Comments: None

Fischer, H.B. 1975. Description of the model, Part I in a numerical model of material transport in salt-wedge estuaries. U.S. Geological Survey Professional Paper 917, prepared in cooperation with the Municipality of Metropolitan Seattle. P 1-8.

Source of Information: U.S. Geological Survey, Tacoma, Washington

Area of Study: Duwamish River Estuary

This paper describes a numerical program which has been used to model the transport of salt and other constituents in one salt-wedge estuary, the Duwamish River estuary.

Water in a salt-wedge estuary ideally is characterized by an oscillating well-mixed wedge of undiluted seawater topped by a series of successively more dilute overlying layers. In the wedge the flow is back and forth, with a net landward component to replace water entrained upward into the overlying layer; in the overlying layers the flow also oscillates, but with a net seaward component because of the input of fresh river water and entrained wedge water. The flow is modeled by a computer program, and the flow is used as an input to the constituent-transport model. The computer program then is used to determine the advection and dispersion of dissolved constituents and plankton, and their concentrations throughout the system in response to given inputs. The report describes required input data and method of operation of the computer program.

The results of the model application are given in Part II of this report. The program can be used to predict the distributions of such constituents as BOD, DO, and plankton, and to predict the effect of changes in the estuarine geometry on these distributions. It is hoped that the program will prove useful in studies of other salt-wedge estuaries.

Value of Information: 3

Comments: None

WATER QUALITY

Gipe, D.C., H.E. Geren, C.T. Nadler, L.A. Reed and J. Sweeney, 1971. Water quality and pollution control, Appendix XII in Columbia-North Pacific Region Comprehensive Framework Study of Water and Related Lands. Pacific Northwest River Basins Commission. Vancouver, Washington, 531 pp.

Source of Information: Pacific Northwest River Basins Commission. Vancouver, Washington.

Area of Study: Washington, Oregon, Idaho, Montana, Wyoming, Utah, Nevada

The water quality and pollution control appendix covers about 174 million acres in the states of Washington, Oregon and Idaho; western Montana; and small portions of Wyoming, Utah and Nevada. The purpose of this appendix is to present the current (1968) status of water quality and pollution control in the Pacific Northwest. The Puget Sound region is designated as subregion 11. This appendix gives a general description of the subregion, its water resources, land uses and pollution problems. Future sources of waste production are speculated on and means to satisfy future demands of the Puget Sound region are discussed. Modified monthly sewage discharge into the Green-Duwamish River and one-in-ten-year monthly low flows are given.

Value of Information: 1

Comments: None

WATER QUALITY

Haushild, W. L. and E. A. Prych. 1976. Modeling coliform bacteria concentrations and pH in the salt-wedge reach of the Duwamish River Estuary, King County, Washington. Open file report 76-415 U.S. Geological Survey. Prepared in cooperation with Metro. 43 pp.

Source of Information: U.S. Geological Survey Library, Tacoma, WA

Area of Study: Duwamish River Estuary

Total and fecal-coliform bacteria, plus pH, alkalinity, and dissolved inorganic carbon are water-quality parameters that have been added to an existing numerical model of water quality in the salt-wedge reach of the Duwamish River estuary. The coliform bacteria are modeled using a first-order decay (death) rate, which is a function of the local salinity, temperature, and daily solar radiation. The pH is computed by solving a set of chemical-equilibrium equations for carbonate-bicarbonate buffered aqueous solutions. Alkalinity and dissolved inorganic carbon are constituents that were added to the model for use in these equations. The required concentrations of Ca, Mg, SO_4 , Na, K, Cl, and NO_3 were calculated from the local salinity and the concentrations of these constituents in the seawater and the freshwater. The model was calibrated with data from the summer of 1971.

Concentrations of coliforms in water near the surface of the Duwamish River estuary commonly are in the thousands of MPN/100 ml. Data indicate a maximum concentration near the Boeing Bridge, adjacent to the upstream end of the estuary model, with decreasing concentrations downstream. Coliform concentrations in the estuary's salt wedge generally increase upstream. Concentrations of total and fecal-coliform bacteria computed by the model for the Duwamish River estuary agreed with observed concentrations within about 40 and 60 percent, respectively.

The variation of pH in the Duwamish River estuary generally is related to the variation of salinity. Water with a higher salinity usually has a higher pH than water with a lower salinity. The pH of the saltwater in Elliott Bay, and therefore in the wedge, is typically 7.8 ± 0.5 , and the pH of the freshwater in the Green-Duwamish River is typically 7.0 ± 0.5 . Mixtures of the two give intermediate values of pH. The pH of estuary water during a phytoplankton bloom is increased by the removal of CO_2 from the water during photosynthesis. A phytoplankton bloom in the estuary increased the computed pH by as much as one unit. The computed pH in the wedge decreases from the estuary mouth to the wedge toe by about 0.3 unit. The computed pH generally agreed with observed pH within about a 0.2 pH unit.

Value of Information: 3

Comments: None

WATER QUALITY

Isaac, G. W., G. D. Farris, and C. V. Gibbs. 1964. Special Duwamish River Studies. Water Quality Series No. 1. Municipality of Metropolitan Seattle. Seattle, Washington, 35 pp.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Green-Duwamish River

Degradation of water quality in the Duwamish Estuary became apparent in August, 1963. To monitor changes in river conditions during this critical summer period, an intensive sampling program was undertaken. The influence of tide, river flow, vertical mixing, upwelling and diurnal fluctuations in water quality were studied throughout the critical period by daily sampling and 24-hour studies. River flow and upwelling were found to be of minor importance. Tidal stage and total tidal exchange were found to correlate closely with changes in water conditions measured in the estuary.

Results of Metro's first summer of intensive sampling revealed that release of 100 cfs of dilution water from Howard Hanson Dam was of little benefit in terms of alleviating serious water quality problems in the lower Duwamish Estuary. The required volume for adequate flushing would not be available except during periods of heavy rainfall. Data indicate that tidal exchange is a major factor in regulating Duwamish water quality. Influences of wastewater discharges, upwelling, river flow and other factors studied appear to be overshadowed by the influence of the tide. The report concludes that it will be possible to predict impending water quality problems by projection of tidal prism information and careful consideration of quantitative variables.

Value of Information: 3

Comments: None

WATER QUALITY

Lenarz, W.H. 1969. Analysis and evaluation of data obtained from automatic water quality monitoring stations on the Duwamish Estuary. Ph.D. Thesis, University of Washington, 189 pages.

Source of Information: U.W. Fish. - Oceanography Library

Area of Study: Duwamish River Estuary

This study gives a method for analysis of large amounts of data from automatic water quality monitoring stations. The purpose was to develop a system that can be used on a real-time basis to track water quality in estuaries.

From February to December, 1966, four stations from just above the Renton sewage plant to the Spokane Street Bridge were monitored. Parameters monitored were temperature, dissolved oxygen, specific conductivity and pH one meter below the surface. At the two downstream stations, temperature, dissolved oxygen and specific conductivity were also monitored one meter above bottom. Measurements were recorded on strip charts at each station and on teletype and punched tape at Metro.

The largest problem was processing large amounts of data. Ten computer programs were written to handle the data. Daily averages were used. Multiple regression was used to describe linear relations among DO and temperature. Spectral analysis was used to describe the periodic nature of the data. Calculations of tidal phase gave estimates of travel time. Data support the hypothesis that algal blooms in the Duwamish Estuary are partially controlled by tidal action.

Value of Information: 3

Comments: None

WATER QUALITY

Malins, D.C. 1980. Pollution of the marine environment.
National Oceanic and Atmospheric Administration - National
Marine Fisheries Service, Environmental Conservation
Division of the Northwest and Alaska Fisheries Center,
Seattle. 32-37.

Source of Information: NOAA-NMFS, Seattle, Washington.

Area of Study: Green-Duwamish River

An interdisciplinary approach in attempting to solve problems in identifying chemical pollution in marine environments is presented using a number of NOAA experiments as examples. One of these experiments deals with relating pollution to biological damage of organisms in the field. Adult English sole living in the Duwamish River estuary were studied and it was found that 32 percent had liver tumors. Although sediments in the Duwamish River estuary are heavily contaminated with industrial wastes, a cause and effect relationship between the pathological lesions and the pollutants in the sediments could not unequivocally be shown.

Value of Information: 3

Comments: None

WATER QUALITY

Miller, D. M., J. A. Wetherall, and W. H. Lenarz. 1967. A modern approach to the study of estuaries, with specific reference to the Duwamish River, Washington. Trans. Thirty second N. Am. Wldl. Nat. Res. Conf. pages 165-173.

Source of Information: U.W. Fisheries Oceanography Library

Area of Study: Green-Duwamish River

Work on the Duwamish River was conducted by U.W. FRI on a 5 year grant starting in 1965 from the US PHS. The objective was to illustrate a total approach to analysis of natural and man-influenced processes.

In the past, Duwamish water quality had been neglected and various domestic and industrial waste discharges had been allowed. By diversion of these wastes away from the river, Metro has begun rehabilitation of the area. Objectives of the study were to: (1) develop a mathematical model to simulate the more important physical and chemical processes, including rates of addition and dilution of contaminants and (2) to investigate the ecology of pelagic and demersal fishes and near-shore marine environments affected by industrial waste discharge. Because the estuary is complex, the computer methods used were time series analysis and simulation analysis. The time series analysis includes tidal, diel, and seasonal cycles of water quality. One of the problems addressed is dealing with very large quantities of data.

The authors felt that the success of the chinook run was probably determined to a large extent by environmental conditions during the period of transition from fresh-to-salt-water life. The extensive study of juvenile chinook in the spring of 1966 gave unreasonable results for mortality. It was concluded that the total system is more complicated than the methods were able to accommodate.

Value of Information: 3

Comments: None

WATER QUALITY

Nece, R. E. and R. A. Lowthian, 1976. Tidal circulation study; proposed southeast harbor development. Technical Report No. 47, Charles W. Harris Hydraulics Laboratory. Department of Civil Engineering, University of Washington. 38 pp.

Source of Information: Port of Seattle, Planning and Research
Department

Area of Study: Elliott Bay

This report presents findings of a physical hydraulic model study performed for the Port of Seattle to determine the effects on tidal currents near the mouth of the East Waterway caused by modifications to piers in the proposed southeast harbor development. Changes in current patterns and velocities caused by partial or complete fill between Pier 36 and Terminal 47 were investigated. The hydraulic model was described in detail and limitations were identified. Effective average velocities over the water column were measured by plotting drogue locations at discrete time intervals. Personnel from the Port of Seattle conducted drogue surveys in the mouth of the East Waterway and off the northeast corner of Harbor Island on October 14 and 15, 1975 to verify the model.

Model tests showed no major changes in current patterns. Small local changes including: a westward deflection of the discharge from the east waterway; a narrow flow separation zone; and increased water exchange between slips and the bay were noted.

In the long term, the filling of slip areas in and north of the East Waterway will eliminate local regions of poor water quality which could exist in back corner areas of the slips under existing conditions. Sediment transported through the East Waterway will be diverted somewhat to the west upon entering Elliott Bay, so deposition in the delta area may be moved to the west as well. Little effect on behavior of the discharge from the West Waterway is expected. There will be less likelihood for stagnant water areas in the slip to be retained between Pier 36 and Pier 37. The various alternatives will not produce any major changes in the overall hydraulics of the East Waterway.

Value of Information: 3

Comments: None

WATER QUALITY

Okey, R. W. 1957. A study of present and future pollutional effects in the Green-Duwamish River. Univ. Wash. M.S. Thesis. 96 pages.

Source of Information: Univ. Wash. Eng. Lib.

Area of Study: Green-Duwamish River

This study was undertaken in 1957 to evaluate pollutional effects and to predict pollutional effects in the Green-Duwamish River. The pollutional factors of concern were pH, saline intrusion, dissolved oxygen, temperature, biochemical oxygen demand and phosphate.

The study was conducted by the analyses of existing data collected by other agencies and by the establishment of sampling stations and a sampling program by the author. The reach of the river under specific study was from Auburn, to its mouth. Data were examined for maximum temperatures, variations in pH, biochemical oxygen demand, dissolved oxygen, phosphate and extent of saline penetration.

The following conclusions are derived from the data and analysis:

1. Saline penetration is significant to a point near the Renton-Tukwila Bridge.
2. The temperatures recorded below Kent indicate need for concern for the downstream migrant salmon.
3. The phosphate levels commence at a low background of 40 ppb above Auburn, and slowly increase to a high of 105 ppb at Spokane Street.
4. The pH values are within a satisfactory range.
5. The dissolved oxygen levels in the estuary section are depressed due to the discharge of sewage and industrial wastes below Auburn and primarily below Renton Junction.
6. Any increase in the dredged estuary will make additional investigation of the dissolved oxygen picture a necessity.

Value of Information: 2

Comments: None

WATER QUALITY

Pavlou, S.P. and R.N. Dexter. 1979. Distribution of polychlorinated biphenyls (PCB) in estuarine ecosystems: Testing the concept of equilibrium partitioning in the marine environment. Environmental Science and Technology. 13(1) 65-71.

Source of Information: UW Health Sciences Library

Area of Study: Puget Sound

Spacial and temporal trends in the chlorobiphenyl concentrations observed in various marine components of Puget Sound between 1973 and 1977 are presented. The distribution and accumulation characteristics are discussed in terms of the physical chemical processes that control PCB flow throughout the ecosystem. For the low levels detected in seawater, the data suggest that uptake is predominantly governed by equilibrium partitioning of the chemicals between suspended phases and ambient water.

Value of Information: 2

Comments: None

WATER QUALITY

Prych, E. A., W. L. Haushild and J. D. Stoner. 1976. Numerical model of the salt-wedge reach of the Duwamish River Estuary, King County, Washington. U.S. Geological Survey Professional Paper 990. Prepared in cooperation with the Municipality of Metropolitan Seattle. 26 pp. + App.

Source of Information: U.S. Geological Survey, Tacoma, WA

Area of Study: Duwamish River Estuary

A numerical model of a salt-wedge estuary developed by Fischer (1975) has been expanded and used to calculate the distributions of salinity, temperature, chlorophyll a concentration, biochemical oxygen demand, and dissolved-oxygen concentration in the Duwamish River estuary, King County, Wash. With this model, which was calibrated and verified with observed data, computed temperatures usually agreed within 2° Celsius of observed temperatures. During a phytoplankton bloom in the summer of 1968, the computed chlorophyll a concentrations increased and decreased with the observed concentrations; however, during two blooms in 1967 the computed high concentrations persisted farther downstream and lasted a few days longer than the observed concentrations. The computed and observed dissolved-oxygen concentrations usually agreed within 2 milligrams per litre, except during phytoplankton blooms. During the blooms, the differences were often larger, especially when the computed chlorophyll a concentrations were larger than the observed concentrations.

The model was used to predict the dissolved-oxygen concentrations in the Duwamish River estuary when the Renton Treatment Plant sewage-effluent discharge is increased to its proposed maximum of 223 cubic feet per second (6.31 cubic metres per second). The computed monthly average dissolved-oxygen concentrations in the estuary decreased by a maximum of 2 milligrams per litre when compared with computations for the summer of 1971, when the effluent discharge averaged 37 cubic feet per second (1.05 cubic metres per second). The increase in effluent discharge is not expected to cause large changes in phytoplankton concentrations in the estuary.

Value of Information: 4

Comments: None

Stoner, J. D., W. L. Haushild and J. B. McConnell. 1975. Model computation of salinity and salt-wedge dissolved oxygen in the Duwamish River Estuary, King County, Washington. Part II in a numerical model of material transport in salt-wedge estuaries. U.S. Geological Survey Professional Paper. 917. Prepared in cooperation with the Municipality of Metropolitan Seattle. p 9-36.

Source of Information: U.S. Geological Survey, Tacoma, Washington.

Area of Study: Duwamish River Estuary

Saltwater from Elliott Bay on Puget Sound forms a wedge in the lower part of the Duwamish River estuary. The numerical model described by Fischer in Part I of this report was used in computing salinity distributions in the estuary, and oxygen-use rates and dissolved-oxygen distributions in the salt wedge. Computed spatial distributions of salinity agreed well with observed distributions during about 30 slack tides in July and August 1968. Analyses of the sensitivity of computed salinity changed most in response to changes in the wedge salinity and the location of the wedge toe.

The rate of use and the concentration of dissolved oxygen (DO) in the salt-wedge were computed by the model for June-August 1968 and for the June-September periods of 1967 and 1969-71. Before 1970, the estuary received discharges of treated, partly treated and raw industrial and municipal wastes; after 1970, the only major source of waste was the effluent from the Renton Treatment Plant, a secondary treatment plant. Attributable to these changes in waste disposal to the estuary were (1) observed wedge DO concentrations generally 2 mg/l greater in 1970-71 than in 1967-69, and (2) oxygen-use rates in the wedge 60 percent greater during 1967-69 than during 1970-71. Analyses of covariance indicate that computed wedge DO concentrations were not different (95-percent confidence level) from observed concentrations, and the standard error of estimate of the computed concentrations ranged from 10 percent (1971) to 22 percent (1967) of the observed mean concentrations. Sensitivity analyses indicate that wedge DO concentration changed proportionally with oxygen-use rate and also was sensitive to changes in the wedge toe location and in the velocity of the water entrained from the wedge.

The model was used to predict the changes that would have occurred in the oxygen-use rate and DO concentrations in the wedge during June-September 1971 if discharge of Renton Treatment Plant effluent had been increased from a 1971 average of 37 ft³/s (63 m³/min) to the planned maximum of 223 ft³/s (379 m³/min). The predictions suggest that (1) the oxygen-use rate would have

(Continued; Stoner et al., 1975)

been increased by 92 percent, (2) a relatively low DO concentration (4 mg/l) would have been decreased by 45 percent, and (3) a relatively high concentration (9 mg/l) would have been decreased by 8 percent.

Value of Information: 4

Comments: None

WATER QUALITY

STR 1972. Effect of Dredging on Water Quality and Sediment Transport in the Duwamish Estuary. Report to the U.S. Army Corps of Engineers, Seattle District by Stevens, Thompson & Runyan, Inc., Seattle, Washington. 64 pp. & App.

Source of Information: Seattle District, U.S. COE

Area of Study: Duwamish River Estuary

Methods:

STR was retained by the Corps of Engineers in July, 1972, to study the effects upon water quality and sediment transport of improving and extending navigation in the Duwamish Waterway. Studies were undertaken to determine the effect of the project on salt water intrusion into the estuary, on sediment loading and upon water quality with respect to initial and maintenance dredging as well as disposal of dredged material. The major factors identified for analysis were circulation patterns, surface water and saline wedge detention times, salt water intrusion, sources and sinks of dissolved oxygen and shoaling rates of sediments.

Nine water quality stations were established in the lower river; seven were used for vertical profiling and five were selected for complete chemical analysis including metals. Laboratory procedures followed the 13th edition of "Standard Methods". Six sediment stations were established to provide representative analysis of the materials to be dredged. Laboratory procedures followed EPA Bottom Sediments Manual (EPA, 1971).

Existing conditions and estuary mechanics were described. Impacts of alternative dredging disposal plans were assessed.

Results:

Results of the water quality data collected for this study analyzed with respect to other available water quality data indicate:

- o dissolved oxygen conditions in the estuary were greater than minimum class B standards (5.0 mg/l for marine waters) during all times of sampling, although lower dissolved oxygen concentrations usually occur later in the summer during low fresh water flow and minimum tidal exchange periods,
- o the spatial variations of such water quality parameters as oil/grease content or iron indicate that discharges of industrial or stormwater origin significantly alter the estuarine water quality.

(Continued; STR, 1972)

Results of the sediment tests indicate:

- o bottom sediments within the waterway which have been deposited to depths up to 5-6 feet have become contaminated to the point of exceeding EPA guideline levels,
- o much of the sediment in the proposed channel improvement exhibits relatively high organic stability, low oxygen demand and low impact on water quality if allowed to settle for 24 hours,
- o of the 4.6 million cubic yards of spoil estimated for disposal with the proposed project, about 212,000 cubic yards fully meet the EPA guidelines for open water disposal. The remaining quantities exceed permissible levels to varying degrees and require special handling.

Conclusion:

The report concludes that the extent of saltwater intrusion and the surface water and wedge detention times are a function of the estuary geometry, tidal heights and freshwater inflow to the estuary. The circulation in the Duwamish River Estuary is such that there is net movement upstream in the saline wedge. The only mixing which occurs is entrainment of water from the wedge to the overlying fresher water. Particulate material does settle from the surface water into the saline wedge.

The lowest dissolved oxygen concentrations have historically occurred at the tip of the salt wedge near the bottom of the channel. Minimum dissolved oxygen concentrations have increased approximately 3 mg/l since 1967, presumably due to the interception of sewage outfalls in Elliott Bay and the closure of the Diagonal Way Sewage Treatment Plant.

Value of Information: 5

Comments: None

WATER QUALITY

STR, 1974. Environmental management for the metropolitan area. Part III Water Quality. Report to the Municipality of Metropolitan Seattle and the River Basin Coordinating (RIBCO) Committee by Stevens, Thompson and Runyan, Inc., Seattle, Washington. 259 pp.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Cedar and Green River Basins

This study is part of a total environmental planning effort (RIBCO) and it was conducted for Metro for the purpose of defining a basin-wide water quality management program in the Cedar and Green River basins. Funding for the study was furnished by the U.S. Environmental Protection Agency (Proj. No. 1GA00037) and by the funds and contributed services of Metro and other local agencies. This report discusses existing water quality conditions within the RIBCO study area, factors affecting water quality and the spectrum of water quality management alternatives. Its intent is to provide the basic tools and information needed to maintain and enhance water quality from both a regional and local standpoint.

Pages 185-189 (Chapter 8) describe the conditions, problems and control measures for the Green-Duwamish River. Historical records indicate that the Green-Duwamish River often exceeds state standards for temperature, dissolved oxygen and total coliform bacteria. Nitrate-nitrogen levels exceed NTAC (1968) criteria to restrict noxious algal growths. Future conditions in the Duwamish River estuary were evaluated for projected levels of effluent quantity from the Renton STP. Toxic conditions are projected in regards to ammonia and dissolved oxygen levels. It is clear from the analysis that ammonia-nitrogen should not be discharged to the estuary at the projected discharge rates. Low flow augmentation have been recommended to resolve potential problems. Modifications to Howard Hanson Dam could increase the storage capacity and allow a 550 cfs continuous additional release during the two-month low flow period. Benefits from a low flow augmentation program include, dilution of Renton STP waste water, increase in dissolved oxygen levels and reductions in diurnal temperatures, ammonia and nutrient levels as well as reductions in the occurrence of algal blooms.

Value of Information: 4

Comments: None

WATER QUALITY

Tilley, L. J. and W. L. Haushild. 1975. Use of productivity of periphyton to estimate water quality. J. Water Pol. Cont. Fed. 47 (8) 2157-2171.

Source of Information: U. W. Fisheries - Oceanography Library

Area of Study: Green-Duwamish River

This report sponsored by the U.S. G.S. uses the productivity of periphyton to establish base line data for detecting future changes in water quality. Field work was conducted in the summer and fall of 1969 and June, 1970.

A description of the Green-Duwamish River is given including drainage areas, stream flow, tidal influence, and dredged areas. Five stations were established, two in the mountains, one in the lowland, and two in the estuary. Glass slides mounted in plexiglass frames, either anchored to the stream bed or floating in the river, were used to gather periphyton growth.

Chlorophyll a was selected as the parameter for measuring productivity. A high variability was found on all the stations, but slides left 3 weeks had the largest variations. Generally, the highest productivity was in the area that had been dredged. The average net primary productivity increases fivefold in the downstream direction. It varies directly with increases in selected nutrients and varies inversely with stream gradient. Algae may not contribute to low DO concentrations in the dredged part of the river because, while periphyton upstream is undergoing a high rate of accumulation, stream flow is very low and scour is at a minimum. Increases in production indicate both increased fertility and those physical changes that increase productivity.

Value of Information: 3

Comments: None

WATER QUALITY

Uchida, B. K. 1978. A profile of water quality in the Cedar-Green River Basins; Areawide water quality plan for King County, Washington. Technical Appendix No. 5. Municipality of Metropolitan Seattle. 350 pp

Source of Information: Metro Library, 821 2nd Ave., Seattle WA

Area of Study: Cedar and Green River Basins

This document defines existing water conditions and problems and the impact of these conditions on existing instream water uses so that decisions regarding the design and implementation of effective water quality management systems can be made. Pages 212-235 and 283-298 include the lower Green River and the Duwamish River subbasin profiles, respectively. Water quality of the Duwamish Subbasin is described below:

In addition to the water quality standards, the State of Washington, Department of Ecology has promulgated an anti-degradation policy (WQ-PS). The classification implies that water quality in the segment is currently not meeting standards and that effluent limitations imposed on point source discharges by application of secondary or best practicable treatment will not improve water quality sufficiently to meet standards. This segment is currently receiving sufficient coliform bacteria to cause violations of applicable standards annually throughout its length. The contamination appears to originate upstream in the Green River system and from periodic overflows of combined sewage in the Lower Duwamish River.

The Duwamish River also receives sufficient nutrients to support a phytoplankton bloom which causes dissolved oxygen standards violations during the late summer. In addition, sufficient oxygen demands from the wastes discharged into the river cause year-round violations of dissolved oxygen standards in the salt wedge. Diurnal temperature variations violate temperature criteria and standards in the surface waters annually during July and August. Low stream flows during months of high insolation appear to cause these violations.

Conclusion:

Several factors significantly influence the water quality of the Duwamish Estuary:

- o The intrusion of saltwater into the Duwamish Estuary alters the circulation pattern and nutrients. BOD and Chlorophyll a in the saline bottom waters increase as a function of upstream distance. This situation is created by the combination of freshwater entrainment and upstream movement of the saltwater wedge.

(Continued; Uchida, 1978)

- o Renton Sewage Treatment Plant discharges 40 cfs on the average. The primary water quality concerns regarding the treatment plant effluent are the potential for ammonia toxicity and nutrient enrichment. Future increases in treatment plant discharges may have more significant impact on water quality in the Estuary if the level of treatment remains the same.
- o Combined sewer overflows discharge 1,438 million gallons of storm and sanitary sewage into the Duwamish Estuary drainage annually. Its impact on the water quality of the estuary is not fully known; however, high concentrations of pollutants have been measured in the effluent.
- o The bottom sediments in the estuary contain high concentrations of heavy metals, pesticides, PCB's and other toxic substances. The source of this pollution can be traced, in part, to combined and storm overflows and accidental spills. Another source of toxic materials is believed to be historic discharges from industrial old treatment plant facilities (i.e., Diagonal Way Sewage Treatment Plant along the lower Duwamish Estuary).

Value of Information: 3

Comments: None

WATER QUALITY

U.S. Army Corps of Engineers. 1967. Duwamish River, Washington, proposed East Channel closure. U.S. Army Corps Eng., Committee on Tidal Hydraulics. 15 pages.

Source of Information: U.S. Army Corps of Engineers, Seattle, WA

Area of Study: Duwamish Estuary

This report summarizes opinions of the U.S. Army Corps of Engineers Committee on Tidal Hydraulics on potential problems from proposed closure of the East Waterway in the Duwamish Estuary.

Descriptions are given of the East and West Waterway channels bridges and cross sections. Maximum current velocities were reported at 3-4.5 mph (1.3-1.8 m/sec.), which restricted the use of the West Waterway for large vessels to times of slack water. The East Waterway carries about 30 percent of the ebb flow and 20 percent of the flood flow.

The various problems and conditions were analyzed and discussed by the committee during their February 1967 meeting. Calculations of cross section and flow gave reasonable current velocities with the East Channel closed. Under these velocities bank stabilization was not considered a problem. Approximately 78 percent tidal exchange occurs in the East Waterway. With the East Channel closed, exchange may be diminished to where pollution could build up in the Waterway.

Value of Information: 3

Comments: None

WATER QUALITY

U.S. Department of Commerce, NOAA, NOS N.D. Monthly tide data tabulations. U.S. Department of Commerce, NOAA, NOS.

Source of Information: Director, Pacific Marine Center Code CPM
National Ocean Survey, NOAA
1801 Fairview Avenue, East
Seattle, Washington 98102

Area of Study: Elliott Bay

Data are available from two stations in the Elliott Bay area; one at Seattle Ferry Terminal and the other at Lockheed Shipyard. Tide gage records are collected from the stations and reduced. The observations are available in the form of monthly tabulations of times and heights of high and low waters; and hourly heights.

Value of Information: 3

Comments: None

WATER QUALITY

Washington Department of Ecology. 1975-1977. State of Washington water quality assessment report. Report #75-8; 77-14, DOE-D-329. 3 Volumes.

Source of Information: Washington Department of Ecology, Olympia, Washington.

Area of Study: Washington State

The purpose of this report is to assess existing water quality in Washington State and to outline water quality management programs presently employed to improve water quality. This is the initial state report as required by Section 305 (B) of the Federal Water Pollution Control Act amendments. Volume II maps, Volume III Washington lakes.

Value of Information: 2

Comments: None

WATER QUALITY

Washington Dept. of Ecology. 1980 (a). Instream Resources Protection Program -- Green-Duwamish River Basin, Water Resource Inventory Area (WRIA) 9. Proposed Administrative Rules. 13pp.

Source of Information: Wash. Dept. of Ecology, Olympia.

Area of Study: Green-Duwamish River Basin

Proposed administrative rules for the Green-Duwamish Instream Resources Protection Program, Chapter 173-509 WAC are covered in this report.

Value of Information: 2

Comments: Replaces regulations found in WDOE 1980 (b).

WATER QUALITY

Wash. Dept. of Ecology, 1980(b). Green-Duwamish River Basin Instream Resources Protection Program, Including Proposed Administrative Rules, and Supplemental Environmental Impact Statement.

Source of Information: Wash. Dept. of Ecology, Olympia.

Area of Study: Green-Duwamish River Basin.

The Green-Duwamish River Basin Instream Resources Protection Program is a set of policies and procedures developed to protect the Green-Duwamish River resource values. Minimum flows are proposed to reduce impacts resulting from future water appropriations. Included are discussions of instream flows, resources, development plans, management in instream flows and current administrative status. A large part of the text is involved with salmon management in the drainage and the effects of increased impoundment of water behind the Howard A. Hanson Dam.

Value of Information: 3

Comments: None

IV. Dredging/Disposal and Fill Studies

1
1
1

Baumgartner, D. J., D. W. Schults, and J. B. Carlin. 1978. Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix D: Chemical and Physical Analyses of Water and Sediment in Relation to Disposal of Dredged Material in Elliott Bay; Volume I: February-June 1976. Technical Report D-77-24, prepared by the Corvallis Environmental Research Laboratory, U.S. Environmental Protection Agency for U.S. Army Corps of Engineers. 215 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

Methods:

Over 100,000 m³ of dredged Duwamish River sediment were deposited in a controlled environmental dump site in Elliott Bay during 1976. Results obtained by monitoring physical and chemical parameters in the water column and sediment were evaluated to gain insight regarding the effects of dredged material disposal in open estuarine waters. Parameters monitored in the water column included: suspended solids, pH, NH₃-N, NO₂ + NO₃, ortho PO₄-P, Cr, Hg, As, and Mn. Parameters monitored in the sediment included: moisture content, Eh, organic C, NH₃-N, ortho PO₄-P, alkaline soluble S²⁻, bulk and interstitial Cr, As, Mn, Hg, and particle size distribution. The monitoring program was conducted before, during, and at several intervals after dumping to determine the temporal and spatial impact associated with the dumping activity.

Results:

The river sediments selected for dumping at the experimental site were highly nonhomogeneous, although on the average sulfide, ammonia, dissolved iron, and total mercury concentrations were several times higher than those at the disposal site. This differential offered promise of successfully delineating the accumulated material on the seabed following disposal, although the disposal site initially was higher in sulfides and mercury than were the reference sites.

Standard elutriate tests were conducted on the river sediments and results suggest that of the constituents measured only ammonia and manganese would be found in higher concentrations in the water column immediately following each barge dumping procedure.

Conclusion:

Data obtained during the disposal operation showed that the dredged material fell rapidly to the seabed when discharged from the barge, as had been expected from the physical consistency and cohesiveness observed in handling samples. Manganese,

(continued; Baumgartner, Schults and Carkin. 1978)

suspended solids, and ammonia were found to be elevated above ambient in the water column at the near-bottom sampling point. Manganese levels were equal to the recommended limit, but such levels were found only a few minutes following each dump and would not be expected to represent an ecological hazard. Long-term water quality monitoring showed only a small increase in suspended solids concentration near the bottom.

Value of Information: 5

Comments: None

WATER QUALITY

Bowen, B., R.F. Campbell, and D.M. DesVoigne. 1977. Special Studies, Construction Crossing of the Green River. In Environmental Monitoring of the Effects of Construction of the Auburn Interceptor. Final report submitted to the Municipality of Metropolitan Seattle by Parametrix, Inc. Document #77-0622-012FR, 105 pp.

Source of Information: Parametrix, Inc., Bellevue, Wa.

Area of Study: Green-Duwamish River

Methods:

The purpose of this study funded by Metro was to document the levels of turbidity and suspended solids resulting from the dredging and backfill operations during the placement of the Green River siphon for the Auburn interceptor near Kent. Installation of the interceptor across the River was conducted during the last full week of August 1976. Because excessive siltation in the stream could lead to a downstream oxygen depression, a predictive oxygen sag curve model was developed according to the classical equations derived by Streeter & Phelps. A discussion of the model is provided. Six sampling stations were established at discrete intervals downstream from the project site. Two stations coincided with Metro's automated terminals located at the Kent-DesMoines Bridge and at the Renton junction. The automated terminal in the Duwamish River was, likewise, monitored.

Data imply that the turbid water resulting from the excavation was similar to peak storm water runoff observed during late winter and spring. The highest suspended solid concentration measured was during the backfill operation, 475 mg/liter, immediately downstream from the site. These levels rapidly decreased further downstream to background levels within 6.0 river miles.

Dissolved oxygen levels measured by the surveys and the automated terminal during the construction period indicate little change as compared to background levels. Oxygen concentrations did not decrease to a 5.0 mg/liter level, deemed critical for the lower Green/Duwamish River by the DOE.

Mathematic modeling to predict the concentration of dissolved oxygen in the lower reaches of the river was found to be both a useful and an accurate administrative tool. According to the model the greatest impact from the disturbed sediment upon the dissolved oxygen concentration of the Green/Duwamish River occurred approximately 1.0 day travel time (18.2 miles) downstream of the excavation site. The maximum oxygen depression was estimated at 0.82 mg O₂/liter. The maximum predicted oxygen depression in the critical region of the Duwamish River was estimated at 0.61 mg/liter.

The report concludes that construction activity had little impact on downstream dissolved oxygen and suspended solids and thus was not likely hazardous to the resident aquatic life.

Value of Information: 2

B-35

Comments: None

WATER QUALITY

Campbell, R.F., J. Dohrman, D. Weitkamp. 1979. Port of Seattle Terminal 107 Water Circulation. Report to the Port of Seattle Planning and Research Department by Parametrix, Inc. Document #79-0529-011DR 41 pp. + App.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Duwamish Estuary

A survey of existing current patterns of the Duwamish River adjacent to Kellogg Island was performed during the summer of 1978. This study was conducted to evaluate the potential impacts of alternative developments of the Port of Seattle's Terminal 107 area. The report summarizes the results of the current study, discusses the alternative development schemes and comments on the effect such alternative would have upon water circulation around Kellogg Island and upon flows in the Duwamish River.

Current velocity and direction measurements, as well as such physical measurements as temperature ($^{\circ}\text{C}$), salinity (0/00) and dissolved oxygen (mg/l), were taken by personnel from the Port of Seattle at four sampling locations adjacent to Kellogg Island. Water currents were measured using a Magnesen Current Meter to estimate water mass transport and to determine the extent of possible current stratification. Data for temperature, salinity and dissolved oxygen were taken with a Hydrolab surveyor. Sampling occurred during a flood tide on July 6 and during an ebb tide on July 21, 1978. River flows during these periods were 532 cfs and 392 cfs, respectively. Measurements were taken at several depths per station, depending on overall water depth at the time of sampling and the degree of saltwater influence.

Although DO depressions are known to occur in the saline wedge in the lower Duwamish River during low flow, minimum values (7.0 mg O_2 /liter) were above 70% saturation and maximum values (8.6 mg O_2 /liter) approached 100% saturation during the July field survey. Current data show that during periods of low fresh water outflow and flooding tides, reversal in the direction of river flow occurs.

A variety of alternative developmental schemes for the Terminal 107 area were assessed and associated impacts for each alternative were described. The major factor determining impacts upon water circulation was the amount of change in the cross-sectional area of the channel

Value of Information: 3

Comments: None

WATER QUALITY

CH₂M Hill, 1976a. Sediment and elutriate tests; southeast harbor. Appendix A in Southeast Harbor Environmental Studies. Report submitted to the Port of Seattle by CH₂M Hill, Inc. 7 pp.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Elliott Bay

This study was conducted to provide basic data for preparation of environmental documents on Port of Seattle proposals in the southeast harbor of Elliott Bay. Bulk sediment and elutriate tests were performed on soil samples taken offshore of piers 37 to 46. These tests are required by the EPA for evaluation of sediments proposed for deepwater disposal.

In January, 1976 nine stations were sampled from depths varying from the mud surface to 22 feet below the mud surface. Surface samples were collected using a clamshell sediment dredge. Samples below the mud surface were taken by a diving team using portable sampling and jetting equipment. Laboratory tests were performed in accordance with EPA directives and practices.

Results of these bulk sediment and elutriate analyses are provided. No comparisons with EPA guidelines for open water disposal are made and no conclusions are presented.

Value of Information: 2

Comments: None

WATER QUALITY

CH₂M Hill. 1976b. Current and tidal regime impact study for the proposed southeast harbor development. Appendix B in Southeast Harbor Environmental Studies. Report submitted to the Port of Seattle by CH₂M Hill, Inc. 11 pp.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Elliott Bay

Methods:

This study was conducted to provide basic data for preparation of environmental documents on Port of Seattle proposals in the southeast harbor of Elliott Bay. Report summarizes a study conducted in 1975 to assess the effects of possible developments on the current and tidal regime of Elliott Bay. Various alternatives include filling the slips between piers to create containerized marine terminals.

Existing conditions are summarized and impacts of alternatives are assessed. Data on currents in the vicinity of Pier 36 to Terminal 46 were obtained using a hydraulic model (see Nece and Lowthian, 1976).

Results:

The model shows a north flow out of the East Waterway and along the shoreline. Current velocities were affected more strongly by the tide, and less strongly by the flow rate of the river. Neither tidal range nor river flow rate changed the flow patterns significantly. According to the hydraulic model, average flow velocities on the ebbs along Pier 36 through Terminal 46 range between 2 centimeters per second for neap tides and river discharge of 300 cubic feet per second (cfs), and 8 centimeters per second for spring tides and a river discharge of 7,300 cfs. The bay's water quality as determined by the dissolved oxygen concentration appears to be strongly related to the rate of flushing. The DO is higher in months of high river flow--January through May--than during the summer and fall months. The DO concentration may be lower in the water in the slips and under the piers where mixing is less than in the center of the waterway. The difference is reported to be less than 1.0 mg/l.

Conclusion:

Development would cause some changes in the current patterns along the waterfront between Pier 37 and Terminal 46. In the Coast Guard slip the current speeds would become greater than for the existing configuration, and would be more likely to swirl in a horizontal eddy bounded by the sides of the slip. Although there would probably be a greater exchange of water between the slip and the bay/river than now occurs on an ebbtide, the discharged water may be trapped by the eddy currents in a flow separation

(Continued; CH₂M Hill, 1976b)

zone just off Piers 37 to 42. Deflection of the East Waterway discharge away from Piers 37 through 42 would allow the flow separation zone to grow longer than it presumably is in the existing configuration.

Water quality in the vicinity of the piers would become more uniform because of greater mixing. Overall turbulence would increase leading to greater exchanges of water.

Value of Information: 3

Comments: None

WATER QUALITY

Hafferty, A.J., S.P. Pavlou and W. Hom. 1977. Release of polychlorinated biphenyls (PCB) in a salt-wedge estuary as induced by dredging of contaminated sediments. The Science of Total Environment. Elsevier Scientific Publishing Company, Amsterdam. 1-11.

Source of Information: UW Fisheries-Oceanography Library

Area of Study: Duwamish River

An evaluation of the input of polychlorinated biphenyls (PCB) in the Duwamish River resulting from the dredging of contaminated sediments is presented. The mean concentrations of PCB during the monitoring period were 12.8 to 24.5 ng/liter in water and 1.03 to 1.77 $\mu\text{g}/\text{gram}$ dry weight in suspended particulate matter. Those values were within the ranges normally observed in the river, suggesting that dredging operations did not induce a significant PCB pulse of potential hazard to the estuary. The fractionation of PCB in suspended particulate matter was determined by computing component concentration ratios, K^N_d . These quantities indicate an enrichment factor of 10^5 from ambient water. Based on the ambient PCB load and normal discharge, the input of PCB into Puget Sound via the Duwamish River was estimated to be 36 kg/year.

Value of Information: 5

Comments: None

WATER QUALITY

LeGore, R.S. and D. M. DesVoigne, 1973.. Absence of acute effects on threespine sticklebacks (Gasterosteus aculeatus) and coho salmon (Oncorhynchus kisutch) exposed to resuspended harbor sediment contaminants. J. Fish. Res. Bd. Canada. 30(8): 1240-1242.

Source of Information: Univ. Wash. Fish. Ocean Lib.

Area of Study: Elliott Bay

The Port of Seattle funded this study of the effects of resuspended sediment on two species of fish. The purpose was to investigate the possible effects of dredging in the Duwamish Waterway.

Sediment samples were taken with a Van Veen grab in December 1971 and March 1972. Samples were chilled on ice until needed. Ten test fish per 10 gal. aquarium were acclimated for 72 hours. The fish were not fed for the duration of the 96 hour experimental period. Sediment doses of 10^3 g/l reduce visibility to less than one inch for 48 hours. The tanks were aerated most of the time except for the last test where the coho were not aerated for the first 48 hours.

Neither coho salmon or threespine sticklebacks showed any effects with doses of 10^3 mg/l or 5×10^4 mg/l. Chemical analysis showed levels of contaminants above limits of EPA standards. Since there was no acute response, this implies that no overwhelming toxicants are present.

Value of Information: 3

Comments: None

WATER QUALITY

O'Neal, G. and J. Sceva. 1971. The effects of dredging on water quality in the northwest. U.S. Environmental Protection Agency, Office of Water Programs, Region X, Seattle, Washington. 76 pp. + App.

Source of Information: U.S. EPA, Region X Library, 1200 6th Ave., Seattle.

Area of Study: Green-Duwamish River

This study provides information regarding background data on river bottom materials, operating characteristics of dredging equipment and spoil disposal practices in the Pacific Northwest. The purpose was to aid in evaluating proposed dredging projects and improve the adequacy of the permit review system.

Active dredging projects were visited to gain insight into operating procedures. Field sampling was conducted to obtain bottom samples for chemical and physical characterization and to measure the effects of active dredging projects on water quality. Literature on environmental problems associated with dredging was also reviewed. Criteria for determining acceptability of disposing dredged material to open waters were developed as guidelines for evaluating dredging projects.

Five stations were sampled in the Duwamish River in January, 1969. Particle size distribution of the sediments was determined and the following chemical parameters were characterized; volatile solids, COD, IDOD, Eh, total phosphorus, Kjeldahl nitrogen and oil and grease. Sediments at each station sampled (up to the 14th Ave. Bridge) were in excess of the open water criteria in every case.

Value of Information: 3

Comments: None

Pavlou, S.P., R.N. Dexter, W. Hom, A.J. Hafferty, and K.A. Kroglund. 1978. Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington; Appendix E: Release and distribution of polychlorinated biphenyls induced by open-water dredge disposal activities. Technical Report D-77-24, January 1978, prepared by the Department of Oceanography, University of Washington for the U.S. Army Corps of Engineers. 546 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

Methods:

This report presents a detailed discussion of the results obtained in a study conducted to evaluate the release of polychlorinated biphenyls (PCB's) during open-water disposal of contaminated dredged material in Elliott Bay. The specific information provided consists of the following:

- a. A documentation of the release of PCB's from the dredged material to the water column during and after disposal of contaminated sediments from the Duwamish River.
- b. An evaluation of the spatial and temporal trends in PCB levels at the disposal site and its immediate vicinity.
- c. An examination of the dependence of PCB residues measured in water, suspended particulate matter (SPM), and sediments on physical and chemical variables (appropriate to each marine phase examined) which might affect the accumulation and release characteristics of these chemicals from the disposed material.
- d. An assessment of the change in the distribution characteristics of PCB's in the impact zone as compared to the prevailing ambient conditions in the area prior to disposal.

Results:

Appendices A' - E' to this volume present the raw data tables, descriptions of materials and techniques, along with the computer program used for PCB data reduction and a sample input and output.

Results suggest that PCB contamination at the dredging site in the Duwamish River was of local origin rather than a result of translocation of spilled material. High PCB concentrations near the mouth of the East and West Waterways appear to be from deposition of suspended and bed-load sediments originating in the River. High levels along the Seattle waterfront are consistent with general distribution patterns from the chronic PCB

(Continued; Pavlou, et al., 1978)

input from sewage overflows. The high, discontinuous and variable nature of background levels of PCB in the disposal zone did not fit the distribution patterns with respect to these predominant sources of contamination in the area. Results suggest an unidentified, highly localized and direct source of PCB contamination near the disposal site.

Conclusion:

Data provide evidence that following disposal there was an impact to the receiving area. The total amount of PCB transferred to the sediments of the Bay off Fourmile Rock was estimated to have approximately doubled the quantities previously present.

Value of Information: 4

Comments: None

WATER QUALITY

Port of Seattle, 1976a. Draft EIS, proposed and potential projects at Terminal 91 (1976-1980) Appendices. Port of Seattle, Planning and Research Department.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Elliott Bay

These appendices include Port policy statements about Terminal 91, environmental field data regarding biology, water quality currents, air quality and noise.

Value of Information: 1

Comments: None

WATER QUALITY

Port of Seattle, 1976b. Final EIS. Proposed and potential projects at Terminal 91 (1976-1980). Port of Seattle, Planning and Research Department.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Elliott Bay

This EIS covers alternative development conditions, apron repair, maintenance dredging, limited slip filling and relocated truck access.

Value of Information: 1

Comments: None

WATER QUALITY

Port of Seattle. 1977a. Monitoring of dredging and dumping for toe of berm and stormwater outfall foundation (P-37/p-42). Southeast Harbor Water Quality Report No. 3. Unpublished. Port of Seattle, Seattle, Washington. 9 pp.

Source of Information: Port of Seattle

Area of Study: Elliott Bay

The Port of Seattle monitored water quality in the vicinity of dredging and dumping activities during the summer of 1977. Water samples were taken in the area around piers 37 and 42 while work was conducted. Turbidity, dissolved oxygen, temperature, and salinity were measured. Dissolved oxygen ranged from 6.5 mg/l to 7.0 mg/l. Turbidity ranged from 1 JTU to 400 JTUs.

No evidence of "mud flows" was found. Dissolved oxygen levels in the dumping and dredging areas were not significantly different from surrounding areas.

Value of Information: 1

Comments: None

WATER QUALITY

Port of Seattle. 1977b. Monitoring of dredging and dumping for toe of berm and stormwater outfall foundation (P-37/p-42). Southeast Harbor Water Quality Report No. 4. Unpublished. Port of Seattle, Seattle, Washington. 5 pp.

Source of Information: Port of Seattle

Area of Study: Elliott Bay

The Port of Seattle monitored water quality in the vicinity of dredging and dumping activities in 1977. Turbidity samples were taken weekly in the area around Piers 37 and 42 while dredging was being conducted. Divers from Parametrix, Inc. made two dives to determine if "mud flows" were a problem. No evidence of "mud flows" was found.

Value of Information: 1

Comments: None

WATER QUALITY

Port of Seattle. 1978. Monitoring of contaminated dredged material dumping at the P-37/P-42 fill site. Southeast Harbor Water Quality Report No. 5. Unpublished. Port of Seattle, Seattle, Washington. 10 pp.

Source of Information: Port of Seattle

Area of Study: Elliott Bay

The Port of Seattle monitored water quality in the vicinity of dredging and dumping activities in 1977 and 1978. Turbidity samples were taken in the area around piers 37 and 42 while contaminated dredged material was being dumped at the fill site. No evidence was found of any movement of turbidity under the turbidity curtain and away from the fill area.

Value of Information: 1

Comments: None

WATER QUALITY

Schell, W.R., E.E. Collias, A. Nevissi, and C.C. Ebbesmeyer.
1976. Trace contaminants from Duwamish River dredge
spoils deposited off Fourmile Rock in Elliott Bay. Re-
port to the Municipality of Metropolitan Seattle by the
College of Fisheries and Department of Oceanography,
University of Washington. 105 pp.

Source of Information: Metro Library, 821 2nd Avenue., Seattle

Area of Study: Elliott Bay

This study concerns the water quality effects of dumping 283,000 cubic yards of dredge spoils from the Duwamish River into Elliott Bay. The circulation system and effects of tidal changes at the disposal site were estimated from the Puget Sound oceanographic model. Currents at the disposal site were measured with drogues, and the results compared with the oceanographic model of Puget Sound. Parameters measured before, during and after the dumping included trace heavy metals, salinity, temperature, dissolved oxygen, nutrients, turbidity, suspended solids, and pH in the water column. Dredge material, sediment cores, and plankton were also collected and measured for trace heavy metals.

The results of the drogue studies show a northward transport of material in the upper 50 m of water during a large ebb tide, and a dilution of 1:4 to 1:5 to dredge spoils clouds during that ebb tide interval. Below 50 m the transport of material is southward and does not depend strongly on tides. The results of trace metal measurements show that the zinc and copper concentrations in a suspended particulate cloud due to dumping, averaged over 78 days of disposal, are less than 5 percent of the amount being released by the West Point outfall. The concentrations of several trace metals and nutrients measured in the water column are within a factor of 1-5 greater than those concentrations measured at other locations in Puget Sound chosen as controls. The results of sediment measurements of cores collected before dumping show net removal of trace metals from the upper 5-7 cm at the disposal site and indicate transport of the fine particles from previous dredge spoils away from the area. The lateral spreading of the spoil occurs only in the immediate vicinity of the disposal area. The plankton samples show the largest trace metals concentration at the disposal site. The problem of trace metals uptake by plankton from dredge spoils requires more sampling, analyses, and possibly special correlation with trace metals.

Value of Information: 4

Comments: None

WATER QUALITY

Stout, V.F., and L.G. Lewis. 1977. Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington; Appendix B: Role of disposal of PCB-contaminated sediment in the accumulation of PCB's by marine animals. Technical Report D-77-24, prepared by National Marine Fisheries Service for U.S. Army Corps of Engineers, 27 pages.

Source of Information: U.S. Army Corps of Engineers.

Area of Study: Elliott Bay

This report describes studies conducted in 1976 investigating the possible transfer to marine animals of polychlorinated biphenyls (PCB's) as a result of the open-water disposal of PCB-laden dredged material. Dredged material from the Duwamish River in Seattle, Washington, was deposited at an experimental site in nearby Elliott Bay. The PCB content of indigenous animals, English sole (Parophrys vetulus) and Alaska and Oregon pink shrimp (Pandalus borealis and P. jordani), and animals caged at the site, spot shrimp (P. platyceros), sea cucumber (Parastichopus californicus), and mussel (Mytilus edulis) was determined. It was not possible to ascertain whether or not marine animals concentrate PCB's as the result of deposition of PCB-laden dredged material. The small increase in PCB level observed in mussels may have been related to the flux of PCB's resulting from the disposal operation. Alternatively, it may have issued from the PCB burden normally carried downstream by the Duwamish River. These data indicate that no obvious changes have occurred in the PCB levels in marine animals in Elliott Bay as the result of depositing PCB-laden dredged material at the experimental site.

Value of Information: 4

Comments: None

WATER QUALITY

Sugai, S., W.R. Schell, A. Nevissi, S. Olsen, and D. Huntamer. 1978. Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix D: Volume II Chemical Dredged Material in Elliott Bay; September-December 1976. Technical Report D-77-24, prepared by the College of Fisheries, University of Washington for Army Corps of Engineers. 130 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

This report presents results obtained in a study conducted to evaluate the extent and duration of changes in chemical characteristics of Elliott Bay, Washington, six and nine months after disposal of dredged materials from the Duwamish River. The seawater, sediment, and interstitial water were analyzed for the following chemical parameters:

- a. Seawater. Suspended solids, arsenic, manganese, mercury, reactive silicate, inorganic phosphate, nitrate, and ammonia.
- b. Sediment. Free and total (acid soluble) sulfide, manganese, chromium, arsenic, mercury, and particle size.
- c. Interstitial water. Arsenic, manganese, reactive silicate, ammonia, and inorganic phosphate.

Temporal, depth, and spatial changes in concentrations of chemical variables were evaluated at disposal and reference sites. The results of analyses showed only minimal changes in trace metal concentrations in the water column above the disposal site, but lower Eh and pH values in the sediments than at the reference site. The manganese, inorganic phosphate, and ammonia concentration values were greater in interstitial waters at the disposal site than at the reference site.

Value of Information: 4

Comments: None

Tatem, H.E. and J.H. Johnson. 1978. Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington; Evaluative Summary. Technical Report D-77-24, Environmental Laboratory. U.S. Army Corps of Engineers. 77 pages.

Source of Information: U.S. Army Corps of Engineers.

Area of Study: Elliott Bay

A multidisciplinary approach was utilized to study the physical, chemical, and biological effects of disposal of contaminated dredged material from the Duwamish River on a deepwater disposal site located in Elliott Bay, Puget Sound, Washington. A pilot survey, conducted in November and December 1975, was followed by a full-scale field assessment program up to 1978.

Observation of individual disposal events indicated that the sediment left the split-hull barges as a well-defined slug and reached the bottom in approximately 25 seconds. A mound of dredged material 2.2 m high was created near the center of the disposal site. There was no physical or chemical evidence which indicated that any of the material reached the two reference sites located east and west of the disposal site. Chemical analyses of the in situ river sediment revealed concentrations of total sulfides and PCB's and interstitial water ammonia significantly higher than those for sediments from the disposal or reference sites. The disposal operation resulted in a rapid pulse of low levels of suspended solids in the water column which lasted less than 30 minutes. Increased levels of dissolved manganese and total PCB's in the water column were associated with the short-term increase in suspended particulate matter.

Chemical analyses of animal tissues collected at the disposal and reference sites indicated that the disposal operation did not result in higher levels of mercury and chromium in test animals. Mussels held at the disposal site for 3 weeks did accumulate PCB's to some extent; however, background levels of PCB's in Elliott Bay waters were found to be relatively high before the operation. No adverse effects on demersal fish or shellfish were demonstrated. These motile animals were found at the disposal site in large numbers during and after the disposal operation. Benthic communities at the center of the disposal site were impacted adversely. The density and biomass data from the central disposal site station indicated fewer animals present after the disposal although the species data showed more species were present. The biomass and density of animals at the corner stations of the disposal site were found to be greater than the values determined for the two reference sites at 3 months after disposal. A number of opportunistic species were found to be actively recolonizing the central stations of the disposal site at 9 months after disposal.

Value of Information: 4

Comments: None

WATER QUALITY

Teeney, F.M., and A.S. Hall. 1977. Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington; Appenix C: Effects of dredged material disposal on the concentration of mercury and chromium in several species of marine animals. Technical Report D-77-24, prepared by National Marine Fisheries Service for U.S. Army Corps of Engineers, 22 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

Specimens of five species of marine organisms indigenous to Puget Sound were collected over a period of nine months for mercury and chromium analysis. The specimens were collected from two environmentally similar sites in Elliott Bay, the disposal site for "polluted" dredged material from the Duwamish Waterway and a reference or control site.

Mercury and chromium concentrations in English sole (Parophrys vetulus), Alaska and Oregon pink shrimp (Pandalus borealis and P. jordani), spot shrimp (Pandalus platyceros), sea cucumber (Parastichopus californicus), and mussel (Mytilus edulis) were not significantly different between the two sites. In all samples, the levels of mercury and chromium were low and did not exceed 0.10 ppm for mercury and 0.91 ppm for chromium. These data suggest that the disposal operation had no apparent effect upon the mercury and chromium concentrations in the five species of organisms studied.

Value of Information: 3

Comments: None

V. Point Source Studies

Buckley, J. A., C. M. Chitmore, and R. I. Matsuda. 1974. Sublethal toxicity of a chlorinated municipal wastewater to yearling coho salmon (Oncorhynchus kisutch). Municipality of Metropolitan Seattle. 19 pages.

Source of Information: Metro Library, 821 2nd Ave., Seattle.

Area of Study: Duwamish River Estuary

Sublethal toxicity of chlorinated municipal wastewater was investigated by this Metro sponsored study. The purpose was to determine the effects of chlorinated wastewater in saltwater habitats, such as near outfalls and in the Duwamish Estuary.

Yearling coho salmon were exposed for 12 weeks to either 0.3%, 1.1%, or 3.6% chlorinated municipal sewage treatment plant effluent with seawater diluent (Average salinity 28‰) under continuous flow conditions. The maximum safe concentration of effluent lies between 0.3% and 1.1% (average total residual chlorine (TRCl_2) content 0.003 and 0.009 mg/l, respectively).

Effluent concentrations of 0.3% produced no sublethal effects on the fish. Concentrations of 1.1% and 3.6% (average content of TRCl_2 0.030 mg/l) resulted in reductions of hemoglobin and hematocrit to levels indicative of anemia. Observations of the erythrocytes revealed lysed and degenerating cells, increase number of circulating immature cells, and abnormal cells. These hematological effects are attributed to the oxidative nature of residual chlorine.

Value of Information: 2

Comments: None

WATER QUALITY

Buckley, James A. 1976. Heinz body hemolytic anemia in coho salmon (Oncorhynchus kisutch) exposed to chlorinated wastewater. J. Fish. Res. Bd Can. 34: 215-224.

Source of Information: U.W. Fisheries - Oceanography Library.

Area of Study: Green-Duwamish River

The Municipality of Metropolitan Seattle sponsored this useful study of anemia in coho salmon to investigate the effects of chlorinated wastewater. Work was done at the Metro Renton Treatment Plant. Coho salmon averaging 4 g were used in 12 groups of 124 fish each. The fish were fed twice daily during the week and once each weekend day and starved 24 hours before blood tests and weight sampling. The tests ran 16 weeks, 12 of which the fish were in control or test water and the last 4 weeks the fish recovered in 100% river water. Total residual chlorine (TRCL₂) ranged from 0.003mg/l to 0.050 mg/l. Blood tests were taken weekly or biweekly.

The two highest TRCL₂ concentrations, 0.050 mg/l and 0.012 mg/l, showed hemolytic anemia and Heinz body inclusions. A partial recovery of hemoglobin and immature erythrocyte levels occurred after the second week. Feeding response of the fish in the two highest concentrations was significantly less than the others, but had increased considerably by the end of the 4 week recovery period. This study recommends that in areas continuously receiving chlorinated wastes, TRCL₂ should not exceed 0.002 mg/l. The EPA proposes a maximum of 0.003 mg/l.

Value of Information: 2

Comments: None

WATER QUALITY

Buckley, J. A. 1978. Acute toxicity of unionized ammonia to fingerling coho salmon. The Progressive Fish - Culturist. 40 (1): 30-32.

Source of Information: U.W. Fisheries - Oceanography Library

Area of Study: Green-Duwamish River

This useful study sponsored by Municipality of Metropolitan Seattle in 1977 investigates the toxicity of unionized ammonia to fingerling coho salmon. It was done at the Renton Sewage Treatment Plant where the effluent regularly contains this compound.

Tests were conducted with duplicate groups of 10 fish exposed for 96 hours to nine concentrations of unionized ammonia. Twenty liter glass containers with flow through water systems were used. Survival time was recorded as time from introduction to end of respiratory movements. Analysis of test and control solutions was as described in Standard Methods or Strickland and Parsons (1968).

Results gave a 96 hour LC_{50} of 0.45 mg/l and a 4 hour LC_{50} of 0.51 mg/l of unionized NH_3-N . The highest concentration tested with no acute effect was 0.178 mg/l. Estimated safe concentration from this study is 0.023 mg/l, which is near the maximum concentration recommended by the EPA.

Value of Information: 3

Comments: None

WATER QUALITY

Gibbs, C. V. 1962. Water quality monitoring program for the Duwamish River. Report submitted to H.E. Miller, Executive Director of Municipality of Metropolitan Seattle. 12 pp.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Green-Duwamish River

This report describes considerations and recommendations to accomplish the recommended sampling program to monitor effects of the wastewater discharge from the activated sludge plant at Renton, Washington upon the Green-Duwamish River. A scope of work is provided and implementation procedures are recommended. Because no data are generated, this document is of little value to the District.

Value of Information: 1

Comments: None

Gibbs, C. V. and G. W. Isaac. 1968. Seattle Metro's Duwamish Estuary water quality program. J. WPCF. Vol. 40. 3:1 p. 385-394. Paper presented at the 40th Annual Conference of the Water Pollution Control Federation, New York, October, 1967.

Source of Information: Metro Library, 821 2nd Ave., Seattle.

Area of Study: Duwamish River Estuary

This relatively old paper describes the history and scope of Metro's involvement in the Duwamish Estuary. In granting approval of the Renton 2^o STP discharge to the river, a comprehensive water quality monitoring program was stipulated to safeguard against possible deleterious effects from the plant. Metro subsequently embarked on the recommended monitoring program considered to be one of the most intensive efforts on a small estuary undertaken anywhere at that time. Four automatic monitors were installed in 1964 at strategic river locations because manual sampling under various tidal conditions was deemed impractical. Dissolved oxygen, pH, conductivity, turbidity and temperature are recorded continuously. Manual sampling is necessary for hydrographic data, nutrients and bacteria. Frequent ecological studies are conducted and a few were described in detail.

Serious water quality deficiencies were evident before "start-up" of the Renton Plant. Depressed oxygen levels in bottom waters of the lower Duwamish River were below the state selected minimum of 5.0 mg/liter. Lowest levels were typically in the area of 16th Ave. S. Bridge (Rm 4.8). Tidal influence was found to have a significant effect as bottom oxygen values reached a daily minimum near lower low water (LLW). Present studies provide the needed background for prediction and prevention of water quality degradation before damage occurs to important biological resources.

Value of Information: 2

Comments: None

WATER QUALITY

Heyward, A.A., R. Finger, R.G. Swartz, S.F. Munger, T.F. Wetzler and W. Turnberg. 1978. A pilot-scale study of chlorination curtailment at the Renton Treatment Plant. Municipality of Metropolitan Seattle prepared in cooperation with the University of Washington. 27 pp. + App.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Green-Duwamish River

For the purpose of obtaining preliminary information on the bacteriological and chemical impacts of chlorination curtailment of secondary effluent on river receiving water, a pilot-scale system providing approximately two days' retention time was constructed. Studies were conducted during November, 1977. Bacteria monitored for survival and/or occurrence in this system were total and fecal coliforms, fecal streptococcus, Pseudomonas aeruginosa, Yersinia enterocolitica, and Salmonella. Chemical parameters monitored included COD, BOD, TSS, VSS, and $\text{NH}_3\text{-N}$. Data for mutagenic agents in unchlorinated, chlorinated, and dechlorinated effluents were also collected. In addition, grab samples of receiving water above, at, and below the treatment plant were processed for Yersinia enterocolitica and Salmonella.

In general, no high levels of bacteria were detected while testing either unchlorinated or dechlorinated effluents in the pilot system. Pathogenic organisms were isolated from effluent-river water samples but at low frequency. Yersinia enterocolitica was shown to be present at sites above, within, and below the treatment plant. Salmonella were detected within and below but not above the treatment plant. In addition, mutagenic agents could not be shown to be present in any of the effluent samples tested. Chemical data indicate that nitrification did not occur within the pilot system.

These data indicated that more detailed studies in situ would not endanger downstream water users.

Value of Information: 3

Comments: None

WATER QUALITY

Malkoff, M. I. 1976. Water quality study and assessment of impacts for the proposed southeast harbor development. Appendix C in Southeast Harbor Environmental Studies. Port of Seattle, Planning and Research Department. Environ. Report No. 76-1. March, 1976. 10 pp. + App.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Elliott Bay

A water quality survey was conducted in the Southeast Harbor (SEH) and Piers 90/91 areas of Elliott Bay between October, 1975 and January, 1976 to provide baseline data and to assess possible impacts of redevelopment alternatives in the SEH area on water quality. In situ water quality measurements included temperature, salinity, dissolved oxygen, and secchi readings. A review of the available literature on water quality data for Elliott Bay was made.

Examination of the field data was done both qualitatively, using graphic methods to display the data, and quantitatively, using Analysis of Variance techniques. The results indicated a fairly uniform distribution of waterquality parameters throughout the Southeast Harbor and Piers 90/91 areas. The influence of the Green-Duwamish River on Elliott Bay water quality was also discussed and found to be more important in the SEH area than at Piers 90/91.

The field and literature-derived data were then combined in an assessment of possible impacts on water quality of proposed SEH redevelopment alternatives. Only localized short-term impacts were found and these were related specifically to construction (dredging and filling) activities. No long-term impacts on water quality were found for any of the alternatives, with the possible (minor) improvement of water quality in the U. S. Coast Guard slip between Piers 36 and 37.

Value of Information: 2

Comments: None

WATER QUALITY

Metro, 1978. . Preliminary survey of toxic substances in the Duwamish Estuary. Municipality of Metropolitan Seattle, Water Quality Planning Division. 16 pp.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Duwamish River Estuary

Metro is currently looking at a broad range of toxic substances to determine what potential toxicants are present in significant amounts in the Duwamish River and what the probable sources are. The ultimate objective is to plan a program to reduce the entry of toxicants to the river. The available literature regarding toxicants in the river was reviewed. Data for PCB's, pesticides, metals, and oil and grease are patchy.

In all cases reported, the levels of PCB, hydrocarbons, and oil and grease in water exceeded EPA criteria for acceptable levels. All values in water for cadmium, mercury, lead, iron and nickel exceeded the acceptable levels but this occurrence is most likely due to insensitivity of the analyses. Copper levels exceeded the standard downstream of East Marginal Way and zinc was reported in excess above Slip 1 and above East Marginal Way. Dissolved oxygen conditions have improved since the 1960s, perhaps influenced by closure of the Diagonal Ave. STP.

The data cited, while limited in scope and quantity, are evidence of very high levels of some toxicants in both the sediments and the water. There is insufficient information however to identify more than one or two general "problem" areas or any probable sources.

Before recommending a specific program for tighter control of toxicants, there is an obvious need to obtain a more comprehensive set of data. A detailed study plan was presented to collect and analyse both water and sediment samples for toxic substances.

Value of Information: 4

Comments: None

Olsen, S. J., 1976. Baseline study of trace heavy metals in biota of Puget Sound. M.S., Thesis, University of Washington, 194 pages.

Source of Information: U.W. Fisheries - Oceanography Library

Area of Study: Duwamish River Estuary

This study of trace metals in Puget Sound biota was to establish baseline information and to relate that information to man made sources, especially sewage outfalls. Work was funded by the Municipality of Metropolitan Seattle and performed by the U.W. Laboratory of Radiation Ecology.

Samples were taken from areas of sewage outfalls including the mouth of the Duwamish River. As a comparison, samples were also taken from areas remote from any outfalls. Water, plankton, benthic organisms, and pelagic fish were collected at each location. Efforts were made to collect all the samples from one area at the same time. No metal was allowed to touch the samples from collection to final analysis. Three procedures were used to analyze the samples, atomic absorption spectrophotometry, neutron activation analysis, flameless atomic absorption.

Organs from English sole were used to investigate location differences in a fish species. The following trace metals were found to be elevated in some Metro sewage outfall areas; Pb, Cd, Cu, Cr, and Zn. In plankton only Zn and Cu were found to be elevated in outfall areas. Location differences are given for some benthic algae and animals.

Value of Information: 3

Comments: None

WATER QUALITY

Peterson, D. R., A. Livingston, and J. H. Behlke. 1955. An investigation of pollution in the Green-Duwamish River. Technical Bulletin No. 20. Washington State Pollution Control Commission, 22 pages.

Source of Information: U.W. Fisheries - Oceanography Library.

Area of Study: Green-Duwamish River

This report gives an evaluation of the pollution in 1955 of the Green-Duwamish River with respect to coliform bacteria, dissolved oxygen (DO), domestic sewage, and industrial wastes. Domestic water supplies, irrigation and fisheries uses of the river are reviewed. Surveys were made of domestic sewage and sources of industrial wastes.

Samples were taken from 13 stations along the river from above Auburn to the East and West Waterways. Samples were analyzed for DO, coliform bacteria and pH.

Average coliform bacteria were greatest, 36,321 per 100 ml water, in the East Waterway, and lowest, 296 per 100 ml water, above Auburn. DO was generally greater than 6.0 ppm, but fell below 5.0 ppm on August 31, and on September 14, 1955 in the lower river. From sewage surveys, estimates were made of flow, BOD, and population equivalents. Industrial waste surveys specify the amount and type of materials contributed by each source. Potential water uses are enumerated, including domestic and industrial water supplies, fish habitat, irrigation, industrial pollution abatement.

Value of Information: 3

Comments: None

WATER QUALITY

Santos, J. F. and J. D. Stoner, 1972. Physical chemical and biological aspects of the Duwamish River Estuary. King County, Washington: 1963-1967. U.S. Geological Survey water-supply paper 1873-C. Prepared in cooperation with the Municipality of Metropolitan Seattle. 74 pp.

Source of Information: U.S. Geological Survey Library; Tacoma, WA

Area of Study: Duwamish River Estuary

Methods:

This report describes the significant results to 1967 of a comprehensive study that began in 1963 to evaluate what changes take place in the Duwamish estuary as the loads of raw and partially treated industrial and municipal wastes are replaced by effluent from a secondary treatment plant. The estuary is well stratified (salt-wedge type) at fresh-water inflows greater than 1,000 cfs, but when inflow rates are less than 1,000 cfs the lower estuary grades into the partly mixed type. The cross-channel salinity distribution is uniform for a given location and depth. Salinity migration is controlled by tides and fresh-water inflow. At inflow rates less than 600 cfs and tide heights greater than 10 feet, some salinity has been detected 16.1 kilometers (10 miles) above the mouth of the estuary. Studies using a fluorescent dye show that virtually no downward mixing into the salt wedge occurs; soluble pollutants introduced at the upper end of the estuary stay in the surface layer (5-15 ft. thick). On the basis of dye studies when fresh-water inflow is less than 400 cfs, it is estimated that less than 10 percent of a pollutant will remain in the estuary a minimum of 7 days.

Results:

Four water-quality stations automatically monitor DO (dissolved oxygen), water temperature, pH, and specific conductance; at one station solar radiation also is measured. DO concentration in the surface layer decreases almost linearly in a downstream direction. Minimum DO concentration in the surface layer is usually greater than 4 mg/l. The lowest DO values are consistently recorded in the bottom layer at the station 7.7 kilometers above the mouth; monthly means of less than 3.0 mg/l of DO have occurred at this point. Manual sampling shows that the DO sag in the bottom layer oscillates between 7.7 and 10.4 kilometers above the mouth of the estuary. Multiple-regression analysis shows that the surface DO content can be estimated from the fresh-water inflow and water temperature. Tidal exchange and fresh-water inflow indirectly control the bottom DO content. Information available from previous studies failed to indicate a progressive decrease in DO content during the period 1949-56, but data from the present study suggest a slight general decrease in the annual minimum DO concentrations in both the upper and lower layers. Average nitrate concentrations in the fresh water layer have increased progressively since 1964 by amounts greater than those which can be attributed to the Renton STP.

(continued; Santos and Stoner, 1972)

Conclusion:

BOD in both surface and bottom layers is generally less than 4.0 mg/l of oxygen, but values greater than 6.0 mg/l have been measured during a period of phytoplankton bloom. Phytoplankton blooms can occur during periods of minimum tidal exchange and fresh-water inflows of less than 300 cfs if solar radiation and water temperature are optimum. Nutrients (nitrogen and phosphorus compounds) do not control the occurrence of a bloom, because sufficient quantities of these nutrients are always present. Nutrients in the treated effluent may increase the biomass of the bloom.

Value of Information: 4

Comments: None

WATER QUALITY

Tilley, L. J., and W. A. Dawson. 1971. Plant nutrients and the estuary mechanism in the Duwamish River Estuary, Seattle, Washington. U.S. Geological Survey Prof. Paper 750-C, pages C185-C191.

Source of Information: U.S. Geological Survey, Tacoma, WA

Area of Study: Duwamish River Estuary

The U.S. Geological Survey in cooperation with the Municipality of Metropolitan Seattle engaged in an important long term study of the influence of waste disposal upon the Duwamish River. This paper, which addresses the distribution of plant nutrients, is from data gathered between March 1967 and July 1968.

Nine stations between the Renton sewage treatment plant and the Spokane Street bridge were sampled. Six surface stations took fresh water and mixed fresh and salt water, and three bottom stations took water from the salt wedge. Daily samples were analyzed for total phosphate, soluble phosphate, particulate phosphate and ammonium ion.

Surface nutrient concentrations increase in the vicinity of the sewage plant, and decrease at each station downstream. Nutrient concentrations increase with a decrease in fresh water inflow and it was concluded that increased concentrations do not necessarily indicate a greater nutrient load. In the salt wedge, concentrations increase from the mouth upstream. Two possible mechanisms to explain the increase of nutrients in the salt wedge are: mixing with the fresh water, sinking of nutrients via particles or plankton into the salt water. Nutrient patterns can provide additional insight into residence times of waters in various parts of the estuary.

Value of Information: 4

Comments: None

WATER QUALITY

Tomlinson, R.D., B.N. Bebee and R.G. Swartz, 1976. 1976 combined sewer overflow studies. Municipality of Metropolitan Seattle. 104 pp.

Source of Information: METRO Library

Area of Study: Elliott Bay

Tabular data on the volume and concentrations of nutrients, suspended solids, oil, PCB, insecticides, metals and coliform organisms found in combined sewer overflows are given. Dye studies on two regulators, Denny Way and Hanford, and two outfalls, Madison Park/Lake Washington (outfall 023) and Roanoke St/Lake Union (outfall 132), are included. Phylogenetic identifications were made of benthic infauna.

Value of Information: 2

Comments: None

WATER QUALITY

Uchida, B. K. 1975. Chlorinated hydrocarbons. Municipality of Metropolitan Seattle. 74 pp.

Source of Information: Metro Library, 821 2nd Ave., Seattle, WA

Area of Study: Duwamish River Estuary and Elliott Bay

Literature was reviewed in 1975 by Metro concerning chlorinated hydrocarbons. This study divided chlorinated hydrocarbons into organochlorine pesticides and polychlorinated biphenyls (PCB's). The following information was reviewed for each group: properties, uses, sources, concentrations in the environment and toxicity.

Local literature cites that PCB's and pesticides are found in the Duwamish estuary and Elliott Bay. Contaminants were found in the sediments and fishes. Metro sewage treatment plants were found to constitute a continuous source of chlorinated hydrocarbons.

A survey of work being conducted in Washington regarding chlorinated hydrocarbons was presented. The following recommendations were made:

Continue present monitoring programs.

Determine the amounts of PCB's in salmon and steelhead eggs, smolts, and adults in the Duwamish-Green River system.

Determine concentration levels in sources to the Duwamish Estuary.

Value of Information: 3

Comments: None

WATER QUALITY

WDOE, 1980. Duwamish River intensive water quality survey.
Draft Report. Washington State Department of Ecology
Water and Wastewater Monitoring Section. 21 pp.

Source of Information: Department of Ecology, Olympia, WA

Area of Study: Green-Duwamish River

Two water quality surveys during low flow conditions (Sept.-Oct.) 1979 were conducted by the DOE to provide data for making decisions regarding a review of the NPDES permit for the Renton STP and for evaluating possible expansion of the facility.

Methods:

Twenty-three parameters including general physical and chemical constituents, coliform bacteria, nutrients, algal pigments and solid residues were measured on a time sequence of 15, 30, 60, 90, 120, 180 minutes, etc. up to 24 hours, downstream of the STP outfall, rather than at fixed stations. Samples ranged between RM 12.3 to RM 2.1. All analytical procedures were performed according to "Standard Methods".

Results:

1. Physical characteristics

- A. Dilution ratios of river water to wastewater were on the order of 4.1 during low flow.
- B. Stream flows routinely reverse due to tidal influence even as far as the STP-RM 12.0 on high tides in excess of 10 feet. As a result, a block of river water will contain a triple dose of effluent each time flow reversal occurs. Dilution ratios fall to 1.1.4 during reversal of flow and represent "average" conditions in periods of low flow.
- C. Travel time RM 12.0-2.1 = 24 hours @ Q = 250 cfs.

II. Water Quality

Renton STP causes the Green/Duwamish River to exceed State standards for temperature and dissolved oxygen and increases levels of nitrite, ammonia and residual chlorine to at or above federal guidelines.

Conclusions:

Assimilative capacity of the river is currently exceeded by wastewaters discharged from the facility.

Value of Information: 5

Comments: None

B-71

Welch, E. B. 1969. Factors initiating phytoplankton blooms and resulting effects on dissolved oxygen in Duwamish River Estuary, Seattle, Washington. U.S. Geological Survey Water Supply Paper 1873-A. Report prepared in cooperation with the Municipality of Metropolitan Seattle. 62 pp.

Source of Information: U.S. Geological Survey, Tacoma, Washington.

Area of Study: Duwamish River Estuary

Methods:

Phytoplankton productivity, standing stock and related environmental factors were studied during 1964-66 in the Duwamish River estuary to ascertain the factors affecting phytoplankton growth in the estuary. A knowledge of these factors in turn permits the detection and evaluation of the influence that effluent nutrients have on phytoplankton production. Factors controlling the concentration of dissolved oxygen were also evaluated because of the importance of dissolved oxygen to the salmonid populations that migrate through the estuary.

Results:

Phytoplankton blooms, primarily of diatoms, occurred in the lower estuary during August 1965 and 1966. No bloom occurred during 1964, but the presence of oxygen-supersaturated surface water in August 1963 indicates that a bloom did occur then.

Conclusions:

Nutrients probably were not the primary factor controlling the timing of phytoplankton blooms. Ammonia and phosphate concentrations increased significantly downstream from the Renton Treatment Plant outfall after the plant began operation in June 1965, and concentrations of nitrogen and phosphorus were relatively high before operation of the Plant and during nonbloom periods. The consistent coincidence of blooms with minimum fresh-water discharge and tidal exchange during August throughout the study period indicates that bloom timing probably was controlled mostly by hydrographic factors that determine retention time and stability of the surface-water layer. This control was demonstrated in part by a highly significant correlation of gross productivity with retention time (as indicated by fresh-water discharge) and vertical stability (as indicated by the difference between mean surface and mean bottom temperatures). The failure of a bloom to develop in 1964 is related to a minimum fresh-water discharge that was much greater than normal during that summer. Hydrographic factors are apparently important because, as shown by studies of other estuarine environments, phytoplankton production increases when the zone of vertical turbulent mixing is not markedly deeper than the compensation depth.

(Continued; Welch, 1969)

Phytoplankton cells produced in the surface waters sink, thereby contributing oxidizable organic matter to the bottom saline-water wedge. The maximum BOD in this bottom wedge occurs in the same section of the estuary and at the same time as the maximum phytoplankton biomass (as indicated by chlorophyll a) and minimum DO. Other sources of BOD occur in the estuary, and conditions of minimum discharge and tidal exchange assist in reducing DO. Nonetheless, the highly significant correlation of chlorophyll a with BOD throughout the summer indicates that respiration and decomposition of phytoplankton cells is clearly an important contributor of BOD.

Increases in the biomass and resultant BOD of blooms because of increased effluent nutrients presumably would further decrease the concentration of DO. This possible effect of effluent nutrients was evaluated by laboratory bioassays and by a comparison of mean annual biomasses in the estuary. A green algal population in vitro did increase in response to added effluent nutrients; however, the available field data suggest that a 46-percent increase in effluent discharged between 1965 and 1966 did not increase the estuary's phytoplankton biomass significantly.

Value of Information: 3

Comments: None

WATER QUALITY

Welch, E. B. and W. T. Trial. 1979. Ammonia toxicity affected by pH and nitrification in the Duwamish River Estuary. Draft report to Brown and Caldwell Engineers by the Department of Civil Engineering, University of Washington, Seattle. 17 pp. + App.

Source of Information: Metro Library, 821 2nd Ave., Seattle, WA

Area of Study: Duwamish River Estuary

Methods:

To plan for expansion of the wastewater treatment facilities at Renton, it was desired to know if a potential problem of ammonia toxicity presently existed in the estuary, the extent of that problem, and the rate at which ammonium (NH_4^+) is decreased downstream from the effluent input, through nitrification. This report describes results of a study conducted during the late summer and early fall of 1979 to determine ammonium, nitrate plus nitrite, and total N changes downstream from the RTP, and rates of nitrification in situ and in vitro, as well as other water quality characteristics; DO, pH, specific conductance, temperature, and chlorophyll a. Water samples were collected at high and low tide at the following stations:

Upstream of Mouth

Renton Junction Bridge	21.0 km
Renton STP	20.5 km
Cherry St. Bridge	16.2 km
119th St. and Foot Bridge	13.2 km
Boeing Bridge	10.4 km
16th Ave. S. Bridge	7.7 km
1st Ave. S. Bridge	5.6 km

Samples were collected from the surface at each station and at depths of 1, 3 and bottom +1 meter at various stations using a Van Dorn water bottle. In situ measurements of specific conductance, dissolved oxygen, and temperature were recorded at 1 m intervals using a Hydrolab water quality analyzer. The pH was recorded using a portable meter (Graphic Controls Corp.), dissolved oxygen was measured using the azide modification of the Winkler titration method, in addition to the Hydrolab probe determination and chlorophyll a was performed using the fluorometric method.

Results:

Data indicate that a plankton algal bloom did not occur in 1979 and as a result pH did not rise above 8 in the lower estuary. In past years high pH (up to 9 at times) has persisted for part of the day continuously for about 10 days. Ammonium-N content continued to increase downstream from the effluent

(Continued; Welch and Trial, 1979)

input. Although a potentially toxic condition did not occur in 1979, unionized ammonia levels could have approached a lethal level with an intense algal bloom. Nitrification rates in vitro averaged about 0.4 day^{-1} or $800 \text{ ug l}^{-1} \text{ day}^{-1}$ of NH_4^+-N . Nitrification, if operating in the river at the rate in the bottles, should have decreased ammonium downstream to 70 percent of the initial upstream mean concentration of 1215 ug l^{-1} within 5.8 km. However, ammonium increased by 400 ug l^{-1} , which could not be accounted for. The most likely source of the additional ammonium is from river sediments.

Value of Information: 4

Comments: None

WATER QUALITY

Yake, W. E. 1980. The impact of effluent from the Renton Wastewater Treatment Plant on the dissolved oxygen regime of the lower Green/Duwamish River. Draft Report. Water and Wastewater Monitoring Section, Washington State Department of Ecology, Olympia, Washington. 19 pp.

Source of Information: WS DOE, Olympia, Washington

Area of Study: Green-Duwamish River

Methods:

An oxygen sag model was formulated based upon a model developed by J. Yearsley US EPA Region X (Yearsley 1976, 1978) and adaptations to the classical Streeter-Phelps equation. The model was valid for only the fresh water portion of the river (RM 6.0-12.0). All rate constants, except the reaeration rate constant, and all model inputs were determined from field measurements. A description of the major model elements and assumptions are included. A listing of the model and model outputs are appended.

Results:

The predicted oxygen depletion curve fit well with actual measurements. Oxygen reductions on the order of 2.0-3.0 mg/liter were projected near RM 6.0 during the September to November, 1979 low flow conditions. Oxygen depletion due to nitrogenous O_2 demand was 20 times greater than depletion attributable to carbonaceous BOD. Thus, instream nitrification appears to bear the primary responsibility for depressed DO in the river. The model predicts severe oxygen depletion under projected 1985 low flow conditions (reductions on the order of 5.0-6.0 mg/liter at RM 6.0).

Conclusion:

Effluent from the Renton STP is responsible for oxygen depletion in the lower Green/Duwamish River during low flow conditions. Nitrification accounts for greater than 95% of the instream oxygen demand.

Value of Information: 5

Comments: None

WATER QUALITY

Yearsley, J. and K. Mosbaugh, 1976. Permit limitations for the METRO Renton sewage treatment plant. Agency memorandum to G. Courson, May 10, 1976, 5pp.

Source of Information: US Environmental Protection Agency

Area of Study: Duwamish River

Estimates of fecal coliform concentrations, heavy metals, chlorine residual as well as the dissolved oxygen depression caused by the discharge of carbonaceous and nitrogenous BOD are listed in this brief report. Equations for modeling background constituent concentrations and dissolved oxygen depressions are given.

Value of Information: 3

Comments: None

VI. Accidental Spills

WATER QUALITY

Blazevich, J. N., A. R. Gahler, G. J. Vasconcelos, R. H. Rieck and S. V. W. Pope. 1977. Monitoring of trace constituents during PCB recovery dredging operations; Duwamish Waterway. U.S. Environmental Protection Agency, Surveillance and Analysis Division, Laboratory Branch, Region X, Seattle, Washington. 67 pp. + App.

Source of Information: U.S. EPA Region X Lib., 1200 6th Ave., Seattle, Washington

Area of Study: Duwamish Waterway

This report describes the monitoring program conducted after a spill of 255 gallons of transformer fluid, Aroclor 1242, occurred in the Duwamish River in Seattle, Washington on November 13, 1974. A detailed evaluation is presented of data acquired prior to, during, and after the three month recovery operation. An initial recovery effort conducted by EPA resulted in a 30 percent removal of the PCB. The Department of Defense, acting through the Corps of Engineers, removed the remaining Aroclor using a Pneuma dredge. This removal operation increased the total PCB recovered to approximately 92 percent.

The second recovery effort was conducted without significant redistribution of toxic materials and bacteria associated with the dredged sediments. No appreciable amount of PCB returned from the disposal ponds to the river because of the design of the land disposal area and of the use of a filtration-absorption treatment unit. Water, which drained from the dredged spoils in the disposal pond, contained some Mn, N-NH₃, N-TKN, oil and grease, and total coliform, but only traces of Cd, Fe, Zn and total P. Apparently most of the pollutants and bacteria were associated with or scavenged by particulate matter and settled in the disposal ponds. Only small concentrations of toxic materials, nutrients, and suspended solids were observed to be released into the overlying river water during dredging operations.

The release of pollutants from sediments during dredging could be only partially predicted by use of the elutriate test and evaluation of the interstitial water. The elutriate test was valid for most metals, nutrients, and oil and grease. However, both tests failed to predict the amount of PCB released.

Value of Information: 5

Comments: None

WATER QUALITY

Dalseg, R. 1976. Tracing polychlorinated biphenyls in the Seattle area. Municipality of Metropolitan Seattle.

Source of Information: Metro Library, 821 2nd Ave., Seattle, WA

Area of Study: Elliott Bay and Duwamish River

Polychlorinated biphenyls (PCB's) have been found to have lethal and sublethal effects. This important review of Metro data evaluates the PCB emissions in the Seattle area. In 1973, Metro started its own sampling and analysis program. Methods for extraction and gas chromatograph analysis were adopted from the U.S. Environmental Protection Agency and are outlined.

In 1973, the highest concentration in sewage effluent was from a stormwater sewer (0.52 ppb). The contamination source in the Duwamish River was located between the mouth and slip 4 during 1974. In November of the same year, a PCB spill occurred when a transformer was broken in the lower river area.

Most PCB's that enter the sewage treatment plants are removed by the treatment process, and end up in the digested sludge. Effluent concentration range from 0.01 to 0.84 ppb and sludge concentrations range from 15 to 225 ppb.

According to unpublished EPA data, generally higher concentrations of PCB's are found in Puget Sound fish and mammals compared to surrounding areas. In spite of this, average Metro sewage concentrations are among the lowest in the nation.

Value of Information: 3

Comments: None

C. FISHERIES

I SUMMARY

The studies pertaining to fisheries cover a number of subjects including stock assessment, and the effects of disposal of solid wastes and waste waters upon these stocks. To gain a basic ecological overview of the Green-Duwamish system, one should refer to Estuarine Ecology (Salo, 1967). A comprehensive examination of the river's fishes may be found in Fishes of the Green-Duwamish River (Matsuda et al., 1968).

Timing of the anadromous salmon runs, both upstream and downstream is of importance in planning, construction and development projects in the river. Upstream runs are discussed in Study of the Migration and Spawning Distribution of the Runs of Chinook and Coho in the Green-Duwamish River System in the Fall of 1965 (Miller and Stauffer, 1967). Timing, magnitude and pattern of downstream migrating juvenile salmon are available in Program of Study of the 1966 Downstream Migration of Chinook and Silver Salmon in the Duwamish Estuary and Elliott and Everett Bays (Miller, 1966).

Pathological effects of contaminants in the Green-Duwamish River are discussed in Ecological and Disease Studies of Demersal Fishes in Puget Sound near Metro-operated Sewage Treatment Plants in the Duwamish River (Miller et al., 1977). The effects of disposal of dredged materials on demersal fish and shellfish at disposal sites is described in Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington (Hughes et al., 1978). Dissolved Oxygen and its Influence on Three Bottom Dwelling Species in the Duwamish Estuary (Matsuda and Domenowske, 1971) represents comparisons of poor and improved oxygen conditions on bottom species.

II FISHERIES INFORMATION SOURCES

<u>Agency</u>	<u>Telephone Contact</u>	<u>Written Response</u>	<u>Personnel Visit</u>
Federal:			
US Fish and Wildlife Service	Yes	No	No
National Marine Fishery Service	Yes	No	Yes
US Army Corps of Engineers	Yes	Yes	Yes
US Geological Survey	Yes	Yes	Yes
State:			
Department of Fisheries	Yes	Yes	Yes
Department of Game	Yes	No	Yes
Department of Natural Resources	Yes	No	No
Local:			
Port of Seattle	Yes	Yes	Yes
Municipality of Metropolitan Seattle	Yes	Yes	Yes
Muckleshoot Indian Tribe	Yes	Yes	Yes
Universities:			
University of Washington			
. College of Fisheries	Yes	No	Yes
. Washington Cooperative Fishery Unit	Yes	No	Yes
. Fishery Research Institute	Yes	No	Yes
Shoreline Community College	Yes	No	No
Libraries:			
University of Washington	No	No	Yes
Port of Seattle	No	No	Yes
Municipality of Metropolitan Seattle	Yes	Yes	Yes
US Geological Survey	Yes	No	Yes

FISHERIES

Bayha, K.D., C.H. Koski, L.L. Mohler, J.A. Posewitz, W.D. Ray, D.F. Riley, C.F. Simmons and R.E. Vorderstrasse. 1971. Fish and Wildlife, Appendix XIV. Pacific Northwest River Basins Commission. Vancouver, Wash., 453 pp.

Source of Information: Pacific Northwest River Basins Commission. Vancouver, Wash.

Area of Study: Washington, Oregon, Idaho, Montana, Wyoming, Utah, Nevada.

The Fish and Wildlife appendix has three principal purposes: 1) to describe the existing fish and wildlife resources and their use in the Columbia-North Pacific Region; 2) to estimate the future demands for these resources; and 3) to present opportunities and alternatives to meet future fishing and hunting needs through the conservation and development of fish and wildlife resources. The appendix is limited primarily to available (1968) basic data and covers only areas and species dependent upon or affected by fresh water. The Puget Sound region (subregion 11) is discussed in general with one passing comment on the Green-Duwamish River system.

Value of Information: 1

Comments: None

FISHERIES

Bostick, W. E. 1955. Duwamish River seining studies. Puget Sound Stream Studies, Wash. Dept. Fish. 2 pages.

Source of Information: Wash. Dept. Fish., Olympia, Washington

Area of Study: Duwamish River Estuary

This study was undertaken to determine the distribution pattern and time of residence within the Duwamish Estuary of seaward migrating chinook, coho, and chum salmon. Sampling occurred from April to July 1955.

Seining was done at six stations in the estuary. Stations were chosen for the various current conditions existing at each location. A total of 4882 fish were caught and 92% were marked with fin clips. Marked fish were released immediately after being caught, in the same area where they were collected.

Migration of the three species of salmon was found to overlap. Chum salmon peaked first on May 6. Coho peaked four days later on May 10 and chinook salmon peaked two weeks later on May 24. The most outstanding characteristic of the migration patterns was that chum and coho salmon apparently migrate to salt water immediately while chinook salmon reside in the estuary for considerable lengths of time.

Value of Information: 2

Comments: None

FISHERIES

Becker, C. D. 1967. The Green River Hatchery, Washington:
A historical and statistical review. Univ. Wash., Fish.
Res. Ins. Cir. No. 67-1.

Source of Information: Univ. Wash., Fish. Ocean. Lib.

Area of Study: Green-Duwamish River

This review of the Green River Hatchery addresses changes in the watershed, and data from published and unpublished records and literature on salmon production and adult returns. This publication was funded by a grant from the U.S. Pub. Health Serv. to Univ. Wash. Fish. Res. Inst.

The Green-Duwamish River system originally drained watersheds of the White, Green, Black, and Cedar Rivers and the Lake Washington basin. A flood in 1906 diverted the White River into the Puyallup River. In 1916 the Cedar River was diverted into Lake Washington and the Black River was dried up by the lowering of Lake Washington.

The Green River Hatchery was constructed in 1901. History of the hatchery, construction, problems, and highlights of production are given in a chronological account of the years 1901 to 1966. Statistics are listed for production and returns of chinook and coho salmon for 1903 through 1965.

Value of Information: 2

Comments: None

FISHERIES

Burns, D., and L. Brown. 1975. The development of in-season sport catch estimates for the Green River steelhead fishery. Wash. Dept. Game, Progress Report, Project No. AFS-53-1. 14 pages.

Source of Information: Wash. Dept. Game, Seattle, Wash.

Area of Study: Green-Duwamish River

Techniques were developed by Wash. Dept. Game to provide in-season sport catch estimates for the 1974-75 steelhead run. The need for such estimates was determined by the expected heavier than normal fishing pressure during that year.

It was determined that sampling had to take place on 70-80 percent of the available days in the season (December 1974 through March 1975) to give estimates with a \pm 20 percent reliability. Flights were made to count the number of anglers. Creel censuses were also taken to determine the number of hours fished and number of fish caught by each fisherman.

The addition of the bi-weekly catch estimates yielded a total estimate for the season of 4,814 fish. Some recommendations are given for application of these techniques to future in-season estimates.

Value of Information: 2

Comments: None

FISHERIES

Dohrmann, J. 1977. Report on Trident fill operations at Terminal 37, Southeast Harbor area. Port of Seattle, unpublished report. 4 pages.

Source of Information: Port of Seattle

Area of Study: Elliott Bay

This report discusses the effects of fill operations on fish and water quality. In the summer of 1977 water quality and fish populations were monitored in the vicinity of the fill operation.

Water quality was determined with a Hydrolab unit and turbidity was measured at a local lab from water samples. Juvenile salmon populations were sampled with a beach seine and a purse seine (see Parametrix, 1977).

Juvenile salmon had been found previously in turbid near-shore areas and were found in the fill area before and after dumping of a large load. Dissolved oxygen changed less than 0.5 mg/l from before to after a dump. Turbidity in the upper layers of water did not exceed the level that WDF personnel felt could affect migration patterns.

Value of Information: 1

Comments: None

FISHERIES

Dunstan, W. 1955. Green River downstream migration. Puget Sound Stream Studies, Wash. Dept. Fish. 4 pages.

Source of Information: Wash. Dept. Fish., Olympia, Washington

Area of Study: Green-Duwamish River

Washington Department of Fisheries investigated juvenile salmonids in the Green-Duwamish River to determine timing of migration. Sampling was carried out from February to April, 1955.

Sampling gear consisted of fyke nets mounted on rafts that were anchored in the river. The gear was fished daily. Sampling stations were located two miles apart.

Due to the variability of the catch, an exact time for the peak of migration could not be established for chum salmon. The closest estimate was that the peak occurred between March 20 and April 3. The majority of chum were produced in Burns and Newaukum Creeks, which were located between the two stations.

No migration peaks were seen in zero year coho salmon. Catch data for yearling coho lack continuity, but an apparent increase occurs between April 14-21. Chinook catches had an initial peak on February 18-19, though data indicate that the actual migration may be between April 7-17. Most chinook spawning was determined to take place between Soos Creek Bridge and Neeley Bridge.

Value of Information: 2

Comments: None

FISHERIES

English, T., and R. E. Thorne. 1977. Acoustic and net surveys of fishes and zooplankton. Puget Sound Interim Studies, Municipality of Metropolitan Seattle. 64 pages.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Puget Sound

This work was a joint effort by Dept. of Oceanography and the Fish. Res. Inst. of the Univ. of Wash. for the Metro Puget Sound Interim Studies. The purpose was to accumulate baseline biological information and to determine the effects, if observable, of plumes from Metro's outfalls on some pelagic animals.

Acoustic and net surveys of fish and zooplankton were made during 1975-1976 in central Puget Sound in the vicinity of some Metro sewer outfalls. The abundance of fishes showed substantial seasonal variation, especially juvenile herring. The patches of fishes were typically small and widely dispersed, with striking temporal instability. The abundance of fish eggs and larvae differed over the seasons, with several patterns of geographic distribution. Acoustic observations revealed restricted areas where fewer target organisms were associated with maxima of dye used to track the plume from the West Point outfall. No major or widespread effects of plumes from Metro sewer outfalls were observed using the methods of this study.

Value of Information: 2

Comments: None

FISHERIES

Fujioka, J. T. 1970. Possible effects of low dissolved oxygen content in the Duwamish River estuary on migrating adult chinook salmon. Univ. Wash. M.S., Thesis. 77 pages.

Source of Information: Univ. Wash. Fish. Ocean. Lib.

Area of Study: Duwamish River Estuary

In August, September, and October of 1967 and 1968 migrant adult fall chinook salmon were studied in the Duwamish River Estuary for determination of the effect(s), if any, of low dissolved oxygen content. An experimental group of tagged fish was transported and released above the area of low dissolved oxygen, and a control group was released in the capture area below the same area, and their movement and distribution through the Estuary and arrival at the Green River Hatchery were monitored. Oxygen conditions were determined concurrently with sonic tag monitoring through extensive water sampling so that timing could be related to oxygen conditions in the Estuary.

The results and conclusions follow:

1. Some fish from the experimental (barged) group appeared to have left the Estuary ahead of the main population; nevertheless, there was no significant difference in time of arrival at the Hatchery between the experimental group and the control group.
2. Dissolved oxygen levels were lower and remained low a greater amount of the time in 1967 than in 1968.
3. Fish appeared to have left the Estuary earlier in 1968 than in 1967 and began appearing at the Hatchery earlier in 1968 than in 1967.
4. Migration occurred in 1967 when oxygen concentrations were at the minimal level for the season. Dissolved oxygen content at the surface ranged below 5.0 ppm on every sampling run and reached as low as 3.0 ppm on some occasions during the migration period.
5. A correlation was noted during the early part of the season in 1968 between the location of water of low oxygen content and the location of sonic-tagged fish.
6. The location of water of low oxygen content is affected by tide and riverflow.

Value of Information: 3

Comments: None

FISHERIES

Hughes, J.R., W.E. Ames, D.A. Misitano, and G.F. Slusser. 1978. Aquatic disposal field investigations, Duwamish Waterway disposal site, Puget Sound, Washington; Appendix A: Effects of dredged material disposal on demersal fish and shellfish in Elliott Bay, Seattle, Washington. Technical Report D-77-24, prepared by National Marine Fisheries Service for U.S. Army Corps of Engineers. 105 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

A cooperative research program, sponsored by the Office, Chief of Engineers, U.S. Army, was conducted in Elliott Bay during 1975 and 1976 to determine the effects of disposal of dredged material from the Duwamish Waterway in open water. The study involved several agencies, both public and private, investigating various aspects of the disposal operation. The research described in this report was conducted by the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration to determine the effects of dredged material disposal on demersal fish and shellfish at the disposal site. A standard Marinovich "try net" was used to sample the disposal site and two reference sites. Catches of fish and shellfish were inconsistent at the three sites with respect to numbers and species, indicating a seasonal fluctuation in both abundance and composition. Statistical analyses showed that differences in abundance and composition were significant among the different sampling sites and the different sampling periods. However, experimental design and inherent differences among the sampling sites made it difficult to determine whether the catch differences were attributable to effects of the dredged material disposal or simply manifestations of population fluctuations due to migratory behavior patterns. It was concluded that the quantity of dredged material dumped during the study did not have a lasting detrimental effect on the demersal fish and shellfish populations at the disposal site. The investigators recommend (a) that any future study include a longer period of time for collecting baseline data, (b) that the characteristics of the reference sites be more comparable to those of the disposal site, and (c) that the disposal operations be conducted in a manner similar to that which is used in actual practice so the results might have general application.

Value of Information: 2

Comments: None

FISHERIES

Matsuda, R.I., G.W. Isaac, and R.D. Dalseg. 1968. Fishes of the Green-Duwamish River. Municipality of Metropolitan Seattle. Water Quality Series No. 4. 27 pages.

Source of Information: Metro Library, 821 2nd Ave., Seattle

Area of Study: Green-Duwamish River

This report documents the fish populations in the Green-Duwamish River at the time of the opening of the Renton Treatment Plant. The three year (1964-1966) study was sponsored by Metro.

Thirteen sampling stations were established. Two stations were in the waterway, the other 11 were upstream in the Duwamish River. The waterway stations were sampled weekly and due to lack of time and a feeling by the authors that little information was to be gained at the other stations, the river stations were sampled only once. A 100 foot beach seine was used for sampling.

A total of 30 species were caught. Two species, longnose and speckled dace, were taken in the river only. Other species were taken throughout much of the sampling area. Seasonal abundance was investigated for shiner perch, staghorn sculpin, starry flounder, and chinook salmon. The authors conclude that since the initial discharge in June, 1965, the effluent from the Renton Treatment Plant has had no measurable detrimental effect on the fishes in the study area. The increase in populations of shiner perch is believed to be the result of increased food material in the surface waters. The cause of the staghorn sculpin population increase is unknown; however, benthic fauna samples in the waterway showed an abundance of polychaete worms upon which the sculpins primarily feed. Sampling procedures are described and species obtained are described and tabulated. An appendix contains black and white photographs of the species sampled.

Value of Information: 5

Comments: None

FISHERIES

Matsuda,, R. I. and R. S. Domenowske. 1971. Dissolved oxygen and its influence on three bottom dwelling species in the Duwamish Estuary. Municipality of Metropolitan Seattle.

Source of Information: Metro Library, 821 2nd Ave., Seattle.

Area of Study: Duwamish River Estuary

The influence of dissolved oxygen (DO) is discussed in this useful study by Metro. DO data from 1963 to 1970 from the Duwamish Estuary, and otter trawl data from 1966 to 1970 for three of the DO stations were used as a basis for this study. Three species of fish, English sole, starry flounder and Pacific staghorn sculpin, were used for testing the influence of DO. Data from two years were compared; 1967 represents poor DO conditions, and 1970 represents improved DO conditions.

In 1967 the abundance of fish corresponded directly with the level of DO in the bottom waters. In 1970 other factors including natural migration response seems to be dominant. From 1966 to 1970 starry flounder and Pacific staghorn sculpin decreased in abundance while English sole increased. Data indicate that DO alone is not the cause for the species abundance changes.

Value of Information: 3

Comments: None

FISHERIES

McCain, B. B., K. V. Pierce, S. R. Wellings, and B. S. Miller.
1977. Hepatomas in marine fish from an urban estuary.
Bull. Environ. Contam. Toxicol. 18:1-2.

Source of Information: University of Washington, Fish-Ocean. Library

Area of Study: Duwamish River Estuary

This Metro sponsored study investigated some of the effects of urban wastes on aquatic animals. English sole were collected at 8 stations in the Duwamish River between July 1975 and January 1976. Livers and spleens were excised and fixed in 10 percent formalin. Various stains were used for the histological examinations.

The average frequency of hepatomas in English sole whose livers were examined histologically was 32 percent. No frequency differences between sexes were seen. Insufficient numbers of fish were examined to establish a geographical distribution in the Duwamish River.

Hepatoma containing livers were usually abnormally colored. The colors were either yellow, cream, dark brown, cocoa, or greenish brown, as opposed to the reddish brown color of normal English sole livers. Abnormally colored livers appeared larger than normal, and this was supported by liver weight vs. body weight measurements.

Tumor bearing fish were generally normal in appearance, except that the only two fish in the total sample with fin erosion also had hepatomas. The cause of the hepatomas is not known, although PCBs are suspected because English sole in the Duwamish River are known to contain high levels of PCBs.

Value of Information: 4

Comments: None

FISHERIES

Miller, B. S., B. B. McCain, R. C. Wingert, S. F. Borton, K. V. Pierce, and D. T. Griggs. 1977. Ecological and disease studies of demersal fishes in Puget Sound near Metro-operated sewage treatment plants and in the Duwamish River. Puget Sound Interim Studies, Univ. of Wash., Fisheries Research Institute, Rep. No. FRI-UW-7608 for Metro, 135 pages.

Source of Information: Univ. Wash. Fish. Ocean. Lib.

Area of Study: Green-Duwamish River

This important study of demersal fish in the vicinity of sewage outfalls and in the Duwamish River was funded by Metro and conducted by Univ. Wash., Fisheries Research Institute. The purpose of the three year (1975-1977) study was to: 1) investigate the effects of sewage effluent on fish community structure, 2) investigate the relationship of sewage outfalls to disease incidence and parasite levels, 3) obtain baseline data for comparison to future conditions.

Monthly sampling was conducted with otter trawls and beach seines. Quarterly 24 hour studies were carried out at West Point. Dissolved oxygen and salinity were measured at each netting operation. Eight stations were sampled in the lower Duwamish River. Collateral studies included histopathology, microbiology, induction of fin erosion, chemical analysis, and liver abnormality.

In areas outside of the Duwamish River, 62,858 individuals of 87 species were collected. In this report annual cycles are established and species assemblages are analyzed. Disease and parasite infestation is enumerated.

In the Duwamish River, 8,802 individuals of 29 species were taken. Five species (snake pricklyback, English sole, longfin smelt, starry flounder, Pacific staghorn sculpin) contributed 85% of the 1975-76 catch. Only English sole ages 0, I, and II were found with tumors. Starry flounder with fin erosion were taken all year around. The incidence of fin erosion increased with size and age of the fish. English sole and rock sole were found to be infested with nematodes.

A high incidence of tumors occurs in the Duwamish River fish, though tumors do occur on fish throughout Puget Sound. A high incidence of fin erosion also occurs in the Duwamish River fish. A very low incident of fin erosion is found in fish outside the Duwamish River indicating the causative agent may be confined to the river. The similarity of catch results between this report and those reported by Salo (1969) suggests that the environmental quality of the Duwamish has not changed appreciably.

Value of Information: 4

Comments: None

C-16

FISHERIES

Miller, B. S., C. R. Wingert, and S. F. Bordon. August 1975.
Ecological survey of demersal fishes in the Duwamish River
and at West Point, 1974. Fisheries Research Institute,
University of Washington; METRO. Progress Report Jan-Dec
1974. 35 pp.

Source of Information: Fisheries-Oceanography, University of Washington

Area of Study: Duwamish River Estuary

During 1974, the Fisheries Research Institute conducted sampling of demersal fishes in the Duwamish River and at West Point to obtain data on species composition, distribution, abundance, and community structure, and to obtain information on disease incidence and parasite infestation. Disease studies have emphasized finrot, tumors, and nematode parasites. This progress report describes sampling procedures and preliminary results of these investigations for the year 1974.

Otter trawling stations on the Duwamish are mapped, and a list of species collected are tabulated, along with data on seasonal abundance on the five most abundant species collected. Appendix I lists the common and scientific names of the fishes collected.

Value of Information: 5

Comments: None

FISHERIES

Miller, D. M. 1966. Program of study of the 1966 downstream migration of chinook and silver salmon in the Duwamish Estuary and Elliott and Everett Bays. Univ. Wash., Fish. Res. Inst. Cir. No. 66-12. 8 pages.

Source of Information: Univ. Wash. Fish. Ocean. Lib.

Area of Study: Elliott Bay, Duwamish River Estuary

This report outlines a study of 1966 juvenile salmon that was conducted by the Univ. Wash., Fish. Res. Inst. under a U.S. Pub. Health Serv. grant. The program investigated fish in the Duwamish Waterway, Elliott Bay and Everett Bay.

Objectives of the investigation were: 1) to develop a mathematical model of physical and chemical parameters including rates of pollutant flushing, 2) determine density and distribution of pelagic and demersal fishes, 3) record water quality and compare existing conditions with environmental requirements of salmon and other fishes of economic importance.

The study of juvenile salmon was intended to gather information on:

1. Time, magnitude and pattern of downstream migration.
2. Distribution and movement in estuarine waters.
3. Comparative survival in freshwater and estuarine environments (only for young chinook).
4. Growth patterns at entry and following entry into the estuaries.
5. Relationships between various water quality parameters and survival, growth and distribution (only for young chinook).
6. Relative contribution of hatchery and stream fish to the downstream migration.

The main effort will be devoted to chinook salmon. Information on 2 and 5 was ascertained only for chinook because its procurement entails a multiple mark-and-recapture experiment, which was conducted with chinook.

Fish marking was conducted with fluorescent pigments. Recoveries were made in the river, the Duwamish Estuary, and in Elliott Bay. Similar work was done in the Snohomish River system and Everett Bay.

Chemical and physical data were collected by Metro and the USGS. Metro also conducted routine weekly beach-seine operations in the lower Duwamish Waterway to gather information on the seasonal distribution of resident and anadromous fishes.

Value of Information: 3

Comments: None

C-18

FISHERIES

Miller, D.M. and G.D. Stauffer. 1967. Study of the migration and spawning distribution of the runs of chinook and coho in the Green-Duwamish River system in the fall of 1965. University of Washington F.R.I. Circ. No. 67-4.

Source of Information: University of Washington, Fish. Res. Inst.

Area of Study: Duwamish River Estuary

This study was funded by a U. S. P.H.S. grant to U.W., F.R.I. in the fall of 1965, to ascertain the timing and distribution of the salmon run through the estuary and river and the effects of water quality on the run. A purse seine was used to catch fish to be tagged. Seining was done at two locations in the mouth of the Duwamish. Petersen disc tags were used, and one fish was tagged with a sonic tag and followed for a few days. Most tag recoveries were at the Green River Hatchery. Water samples for dissolved oxygen and salinity analysis were taken during seining. Five surveys of the natural spawning areas were made in October-November.

A total of 1330 chinook and 594 coho salmon were tagged. The salmon spent a month milling in the mouth of the river before starting upstream. The majority migrated during the week of September 15-22. The distribution and migration was closely correlated with rainfall, flow, and barometric pressure. The DO was found to be as low as 3.1 mg/l but did not block migration. The distribution of natural spawners is enumerated with values given for average numbers of spawners per mile for various sections of the river.

Value of Information: 4

Comments: None

FISHERIES

Muller, T., and T. Oppermann. 1975. 1975 Green River steelhead spawning survey. Wash. Dept. Game, unpublished report. 12 pages.

Source of Information: Wash. Dept. Game, Seattle, Washington

Area of Study: Green-Duwamish River

A spawning survey of the 1974-1975 winter run of Green River steelhead was made because of heavier than normal fishing. Work was carried out from March to June 1975.

Four helicopter and one fixed wing aerial redd counts were made on the main channel. Since the tributaries are narrow and shaded by vegetation foot surveys were the best method for those streams. As part of the foot surveys, electrofishing was used to determine presence or absence of juvenile steelhead.

Three tributaries were regarded as polluted and did not have suitable gravel areas for spawning. One tributary had good habitat, but the nature of its confluence with the Green River prevented steelhead from entering the stream. The total number of redds was estimated at 212; 78% were located in the main stem of the river.

Value of Information: 3

Comments: None

FISHERIES

Parametrix, Inc. 1977. Juvenile salmonids during filling of piers 37-42, Port of Seattle. Report to Port of Seattle, Parametrix, Inc. Doc. No. 77-0722-013FR. 19 pages.

Source of Information: Port of Seattle

Area of Study: Elliott Bay

This report describes a survey of the juvenile salmonids utilizing nearshore areas of Elliott Bay during fill operations conducted by the Port of Seattle in the summer of 1977. Fish were collected with beach and purse seines. Observations of the turbidity plume caused by placing fill from bottom dump barges were performed by scuba divers.

Most of the juvenile salmon caught were chinook salmon. Less than 10 percent were chum salmon. Herring and smelt were commonly taken in either the beach or purse seine. Juvenile salmon were found along the beach and along the piers in water as deep as 35 feet.

Turbidity seemed to have no effect on the salmon. The turbidity along the beach generally appeared to be greater than in deep water as a result of wave action. Turbidity conditions, as observed by divers during dumping, are described.

Value of Information: 1

Comments: None

Pierce, K. V., B. B. McCain, and S. R. Wellings. 1978. Pathology of hepatomas and other liver abnormalities in English sole (Parophrys vetulus) from the Duwamish River estuary, Seattle, Washington. J. Natl. Cancer Inst. 60:1445-1453.

Source of Information: UW, Health Sciences Library

Area of Study: Duwamish River Estuary

This Metro sponsored study investigated liver abnormalities from English sole taken during the Puget Sound Interim Studies Program, 1975-1976.

Liver abnormalities were found, by gross and histopathologic examination, in 92% of the English sole from the Duwamish River Estuary. Hepatomas were found in 32% (20 of 62) of the English sole. Other observed liver aberrations included increased fatty vacuolation, congestion, structure disarray, increased size and number of melanin-macrophage centers, centrolobular fatty degeneration and necrosis, increased amounts of perivascular connective tissue, intercellular melanin deposits, and hepatocellular hypertrophy often associated with the presence of bizarre nuclei and/or multiple nucleoli. Livers evidencing microscopic lesions were usually discolored. Livers containing hepatomas were often mottled yellow or tan and brown; occasionally, hepatomas were visible as tan or white nodules. Although the cause(s) of the liver abnormalities has not been conclusively identified, chemical analysis of Duwamish River English sole have detected polychlorinated biphenyl (PCB) levels of about 1.5 ppm (dry wt) in total body tissue. Many of the above-mentioned abnormalities, with the exception of hepatomas, have been observed in fish exposed to PCB's.

Value of Information: 3

Comments: None

FISHERIES

Salo, E. O. 1967. Estuarian ecology. University of Washington Fish. Res. Inst., Progress Report.

Source of Information: University of Washington, Fish. Res. Inst.

Area of Study: Green-Duwamish Estuary

This progress report of studies sponsored by a U.S. P.H.S. grant to F.R.I. is composed of four sections, water quality, juvenile chinook salmon, adult chinook salmon, and demersal fishes. The period covered by the report is June, 1965 to October, 1967.

Four automatic water quality stations were set up in the Duwamish-Green River. The data was run through a series of 8 computer programs for processing and analysis. A correlation between stream flow, tidal prism and dissolved oxygen was found.

Mark and recapture work was done with juvenile chinook salmon to assess mortality, distribution, and timing. Survival estimates for two groups from Green River Hatchery to the mouth of the Duwamish were 0.513 and 0.678. Timing growth and water conditions are discussed. Lamprey wounds were found on about 7% of the fish.

Adult chinook salmon were studied by sonic tagging and tracking. The effect of the DO sag at the 16th Avenue Bridge was investigated.

A 16-ft. beam trawl was used to sample demersal fish from Puget Sound, at Duwamish Head, and in the estuary. Data recorded included length, weight, sex, stomach content, and abnormalities (tumors and parasites). From these data a feeding study was conducted.

Value of Information: 4

Comments: None

FISHERIES

Stauffer, G. D. 1970. Estimates of population parameters of the 1965 and 1966 adult chinook salmon runs in the Green-Duwamish River. M.S. Thesis, Univ. Wash. 155 pages.

Source of Information: Univ. Wash. Fish. Ocean. lib.

Area of Study: Green-Duwamish River

Population estimates of adult chinook salmon were made. The work was funded by a U.S. Public Health Service grant to U.W. Fisheries Research Institute.

Field work consisted of tagging the salmon in the Duwamish Estuary. The fish were caught with a purse seine and a Petersen disc tag was attached to the fish in the cartilaginous area at the anterior insertion of the dorsal fin. Tag recovery was done by sports fishermen and at the Green River Hatchery. Population estimates of 34,599 and 27,523 for 1965 and 1966 respectively, were calculated using the Petersen method. A computer program was written to solve for the point values and the variances of the stratified estimating procedures.

Seven carcass surveys were made in 1966 on a 8 mile section of the river. The carcasses were tagged and if a tagged carcass was recovered later its number was recorded. A minimum of 4,240 natural spawning salmon were estimated for the surveyed section of the river.

Value of Information: 3

Comments: None

FISHERIES

Swift, C. H. III, 1976. Estimation of stream discharges preferred by steelhead trout for spawning and rearing in western Washington. U.S. Geological Survey open-file Report 75-155. Prepared in cooperation with the Washington State Department of Game. 50 pp.

Source of Information: U.S. Geological Survey, Tacoma, Washington

Area of Study: Western Washington

The purpose of this study was (1) to determine the stream discharges and wetted perimeters corresponding to spawning and rearing conditions preferred by steelhead trout at 54 reaches on 18 streams in western Washington, and (2) to develop empirical equations relating the discharges and wetted perimeters to easily measured drainage-basin and stream-channel parameters.

Equations for estimating the spawning and rearing discharges and rearing wetted perimeter at unmeasured stream sites were developed by using multiple-regression techniques and measuring discharges and wetted perimeters. The independent parameters used were drainage area, mean altitude of the basin, reach altitude, reach slope, and average width of reach at toe of bank.

Three reaches above 2600 ft (MSL) in the upper Green River were surveyed. Discharges for preferred depth and velocity of spawning ranged between 200 and 250 cfs.

Determination of stream discharges that are preferred during spawning and rearing of steelhead provides information from which the discharges best suited for fish propagation may be established. However, due to the amount of time and expense required to obtain the data, measurements to determine the discharges preferred at spawning and rearing sites on all streams in western Washington are neither practical nor desirable. Thus, the empirical equations presented in this report may be used to estimate the spawning and rearing discharges and rearing wetted perimeter for steelhead at many stream sites not studied.

Regression equation for the preferred spawning discharge was:

$$Q \text{ (cfs)} = 1.55 \text{ (tw)}^{1.16} \pm 0.28$$

where tw = width at toe of river bank.

The regression equation for preferred rearing discharge was:

$$Q \text{ (cfs)} = 0.164 \text{ (tw)}^{1.42} \pm 0.56$$

Value of Information: 1

Comments: None

FISHERIES

Washington Department of Fisheries, Harvest Management Division.
1977, 1978, 1979. Status of summer-fall chinook or spring
chinook and recommendations for management. Wash. Dept.
Fish., Harv. Mgt. Div. Progress Reports numbered 19, 70,
81.

Source of Information: Wash. Dept. Fish., Olympia

Area of Study: Puget Sound Basin

Three reports covering the years 1977, 1978, and 1979
summarize the status and make management recommendations for
the chinook salmon stocks of the Puget Sound, including the
Duwamish-Green River system. These reports give predictions
of total chinook returns and specify allowable harvest limits.
The reports indicate that pink, chum, and sockeye salmon do not
utilize the river. Report #81 states that such small numbers
of spring chinook occur that no fishery was warranted for 1979.

Value of Information: 2

Comments: None

FISHERIES

Washington Department of Game. 1978. Summer fry abundance, steelhead abundance study. Wash. Dept. Game and U.S. Fish Wildlife Service, Steelhead Program Progress Report. Pages 25-39.

Source of Information: Washington Department of Game

Area of Study: Green-Duwamish River

The objective of this joint study by Washington Department of Game and U.S. Fish and Wildlife Service was to gather baseline information on juvenile steelhead populations in Western Washington tributaries. Surveys of fry abundance were conducted from August to October, 1978.

Nine sites on four tributaries to the Green River were sampled. An electroshocker was used to quantitatively collect fish. Thirty fish from each site were weighed and measured. Physical measurements including length of stream section, total wetted channel width, average depth, average velocity, and stream flow (discharge) were recorded for each location.

Spawning survey results from the previous spring were correlated to fry populations. Combined population estimates for all creeks showed a slight decline in the number of fry/m² from 1976 and 1977 to 1978.

Value of Information: 3

Comments: None

FISHERIES

Weatherall, J. A. 1971. Estimation of survival rates for chinook salmon during their downstream migration in the Green River, Washington. Ph.D. Thesis, Univ. of Wash., 170 pages.

Source of Information: Univ. Wash. Fish. Ocean. Lib.

Area of Study: Green-Duwamish River

The U.S. Public Health Service funded the Univ. Wash. Fisheries Research Institute to conduct this study. The study explores the estimation of survival rates of migrating juvenile salmon for the purpose of salmon stock management. Work was performed on the downstream migrations of 1966, 1967, 1968, 1969.

Marking of juvenile salmon was conducted with fluorescent pigments. Recapture was accomplished with tow nets in the estuary. Two methods were used to analyze the data. The Jackson method was found to be biased for migrating salmon because the initial assumptions were invalid. The second method, as developed in this paper, accounted for random travel time and appeared to provide a better fit to the data.

Survival estimates ranged from 37% to 99%. The fish with the lowest survival rate were large, and had to contend with a very low streamflow. The fish with the highest survival rate (99%) were smaller, but had four times the streamflow of the lowest survival fish.

Value of Information: 2

Comments: None

FISHERIES

Weitkamp, D. E., R. F. Campbell, J. Dohrman and B. Wells. 1979.
Port of Seattle Terminal 107 fisheries study. Draft report to
the Port of Seattle by Parametrix, Inc. Document #79-1120-
034FD. 53 pp. + App.

Source of Information: Port of Seattle, Planning and Research Dept.

Area of Study: Duwamish River Estuary

This report describes a one year study (September 1977-August 1978) of fishes utilizing the Duwamish River Estuary in the vicinity of Kellogg Island (Terminal 107). Studies of the fish resources of the T-107 area were designed to determine the species of fishes present, timing and the use of similar adjacent habitats. These objectives were focused on the juvenile salmonids that might use the Kellogg Island (T-107) area.

The various suggested development alternatives proposed by the Port of Seattle for Kellogg Island include alternatives that would either fill or deepen the shallow water habitat. The objective of this study is to provide a factual basis on which to make decisions regarding the future of the Kellogg Island site.

Fish were sampled at a number of locations utilizing beach seining, purse seining and gill netting techniques. All fish were identified to species, enumerated and measured in the field. Twenty six species of fish were collected. Juvenile chum, coho and chinook salmon were found in both the shallow shoreline habitat and in the near surface deeper water habitat. Chum primarily occurred between April 12 and June 20, 1978. Evidence indicates that three groups of chum migrated through the estuary with peaks in mid-April, late-May and mid-June. Juvenile chinook reached a sudden peak in late-May but continued to be present in moderate numbers into July. Data indicate that chinook were rearing in the estuary for a period of one to two months. Great numbers of coho were collected but only during a brief period, April 27 - May 19, 1978. Data indicate a possible interspecific conflict in the estuary between juvenile coho and chum salmon. Pacific staghorn sculpin, juvenile starry flounder, Pacific herring, surf smelt, shiner perch and snake prickleback were also prevalent in the nearshore collections. It appears the nearshore shallow water habitat of Kellogg Island and adjacent areas is used by the young of several salmonid and non-salmonid fishes. The Kellogg Island site provides a habitat that apparently is not unique, at least in regard to the requirements of these fishes.

Value of Information: 4

Comments: None

FISHERIES

Wellings, S. R., C. E. Alpers, B. B. McCain, and B. S. Miller.
1976. Fin erosion disease of starry flounder (Platichthys stellatus) and English sole (Parophrys vetulus) in the estuary of the Duwamish River, Seattle, Washington. J. Fish. Res. Bd. Canada. 33: 2577-2586.

Source of Information: Univ. Wash., Fish. Ocean. Lib.

Area of Study: Duwamish River Estuary

Fin erosion in two species of Duwamish River fish is characterized in this work funded by Metro and contracted by Univ. Wash., Fish. Res. Inst. Fish were collected from 8 stations in the Duwamish River during 1974 and 1975. Specimens were fixed in buffered 10 percent formalin. A histological examination of fin erosion was conducted.

The average incidence of fin erosion was 8 percent in starry flounder and 0.5 percent in English sole. The incident of fin erosion varied at the different stations. The differences were not considered significant because of the small size of some of the samples.

Fin erosion in starry flounder and English sole most frequently affects the dorsal and anal fins; the caudal fin is occasionally involved, and rarely the pectoral and pelvic fins. There is no difference in the frequency of fin erosion on the pelvic fins of the eyed side vs. the blind side. However, pectoral fins of the blind side are more often diseased than the pectoral fins of the eyed side.

Lesions of fin erosion vary from minor defects to extensive destruction. In the most severe lesions, parts of the fins have lost the bony fin rays entirely and the remaining soft tissue is greatly scarred and deformed. The lesions observed in starry flounders and English sole were largely those of a chronic fibrosing disease with epidermal hyperplasia. The hyperplasia of the epidermis is 2-3 times the normal complement of cells with a corresponding increase in thickness.

Actual causes of fin erosion disease are unknown. The authors believe that two prerequisite conditions are dense pathogenic bacteria populations and environmental stress.

Value of Information: 4

Comments: None

FISHERIES

Williams, W.R., R.M. Laramie and J.J. Ames, 1975. A catalog of Washington streams and salmon utilization, Vol. I, Puget Sound Region. Wash. Dept. Fisheries, Olympia.

Source of Information: Wash. Dept. Fisheries, Olympia.

Area of Study: Puget Sound

This volume catalogs streams in the Puget Sound area and documents salmon utilization as well as various commercial and sport fisheries. All streams do not appear in this volume. The Puget Sound region is divided into 18 Water Resource Inventory Areas (WRIA) based on major stream watersheds each with a separate chapter, or section, in the catalog. The Green-Duwamish drainage is designated Water Resource Inventory Area 09. Its chapter gives a description of the Green-Duwamish drainage with detailed maps, plus salmon production, salmon harvest and conditions that could lead to a complete loss or reduction of the environment's fish production potential. The lower Duwamish River is used as a passage by chinook, coho, chum and pink salmon, and steelhead trout.

Value of Information: 3

Comments: None.

Wolcott, R. S. C., Jr. 1970. A computer simulation approach to the study of the polluttional effects on salmon in the Green-Duwamish River Estuary. Masters Thesis, College of Fisheries, University of Washington. 63 pp.

Source of Information: U. W. Fisheries, Oceanography Library

Area of Study: Green-Duwamish River

This report discusses short term and long term economic effects on various levels of mortality imposed on adult salmon in the lower Duwamish River with the aid of computer simulation techniques and an understanding of population dynamics. Four computer models, HATCHTEST, NATURAL, FISK III and RIVER, were described and used to estimate the effects of various river mortalities on hatchery and natural populations of chinook salmon. Polluttional effects were assumed as mortalities; no cause and effect relationships were described.

Model output suggested that increasing mortality on migrating adult chinook in the estuary had little economic effect until mortality reached approximately 80 percent. When mortality reached 100 percent the production-fishery system required 11 years to restabilize.

Value of Information: 2

Comments: None

FISHERIES

Zebold, S. L. 1970. Inter- and intraspecific comparisons of the diel distributions and the food and feeding habits of five species of demersal fishes from Duwamish Head, Puget Sound, Washington. M.S. Thesis, University of Washington, 76 pages.

Source of Information: University of Washington Fish./Ocean. Lib.

Area of Study: Elliott Bay

On May 13-14, 1966, in a program sponsored by University of Washington, the food and feeding habits of five species of shallow water demersal fishes were examined off Duwamish Head, Elliott Bay. The species investigated were Parophrys retulus, Lepidopsetta bilineata, Citharichthys stigmaeus, Citharichthys sordidus, and Chitonotus pugetensis. A 16 ft. shrimp trawl set up as a beam trawl and a 120 ft. beach seine were used to collect the samples. The trawl was used six times at seven depths from 10-80 m during the 24 hour sampling period. The beach seine was fished every two hours. Fish were measured, preserved with formalin, and stomach contents were analyzed later at U.W. laboratories. Total stomach fullness was estimated and contents were separated to determine the volume of each type of food. Of the five species investigated, 1,089 and 1,207 fish were collected by day and night respectively.

The diel distribution with respect to length and depth was compared within and between the five species. The food and feeding habits within and between species were compared relative to depth, length, time, and sex. Overlap of food was shown between species and between length classes. Greatest differences within each species was between largest and smallest length classes. Gause's rule that sympatric species occupy different niches was substantiated by differences in food habit, behavior, feeding habit, or distribution.

Value of Information: 2

Comments: None

D. OTHER AQUATIC RESOURCES

SUMMARY

Studies identified for this section are those documents dealing with wildlife and aquatic biota other than finfish. Most are concerned with benthic organisms and phytoplankton in the Duwamish River and Elliott Bay or wildlife in the area of Kellogg Island.

The U.S. Army Corps of Engineers Waterways Experiment Station completed a series of studies to assess the effects of dredging and dredge disposal on the benthic and planktonic communities in the lower Duwamish waterway and Elliott Bay. Results of this work are reported in appendices to "Aquatic Disposal Field Investigations Duwamish Waterway Disposal Site, Puget Sound, Washington," and are summarized in Tatem and Johnson (1978). Field data on benthic biota are given in Harman and Serwold (1978) and Hughes, et al. (1978), and in a more recent analysis of the same area by Dexter, et al. (1979).

METRO and the Port of Seattle have sponsored field studies on benthic marine biota both within and adjacent to the study area (Parametrix, 1976; Harman, et al., 1977; METRO, 1977; Armstrong, et al., 1978; and Thom, et al., 1979). The Port has also recently contracted a semi-quantitative survey of Pier 91 (see Section F, on-going research). Data from these surveys has provided the only significant source of baseline information on the shallow-water, nearshore environment of Elliott Bay. These data and dredge disposal study results are incorporated in "Seattle Harbor Navigation Project - Operation and Maintenance, EIS," U.S. Army Corps of Engineers (1979).

Algal standing crop and primary production were assessed by Welch (1968 and 1969), Welch and Isaac (1967), Santos and Stoner (1972), Welch, Emery and Matsuda (1972), Tilly and Dawson (1971), Tilley and Haushild (1975 a and b), Ebbesmeyer and Helseth (1977), and Thom (1978) to evaluate the possible effects of nutrient enrichment in the Duwamish River and Elliott Bay. With the exception of Thom (1978), these studies emphasize water quality problems and only briefly address the algal components.

Few wildlife surveys have been completed and/or are reported in the literature. Most of the work is limited to the uplands and wetlands adjacent to Kellogg Island (i.e. Environmental Management Division, 1976; Zeigler, 1978; and U.S. Army Corps of Engineers, 1979). Field data from other locations are non-existent or generalized as to species and time of occurrence (i.e. Salo, 1975; Wahl and Paulsen, 1971; and Fish and Wildlife Technical Committee, 1970).

Data appear to be lacking on macroinvertebrates within the upper Duwamish waterway, and on the nearshore biota in areas other than those noted above. Also, with the exception of the dredge study results (Tatem and Johnson, 1978), none of the study results are adequately quantified to distinguish locational and seasonal fluctuations in abundance, species composition and diversity.

INFORMATION SOURCES

<u>Agency</u>	<u>Telephone Contact</u>	<u>Written Response</u>	<u>Personal Visit</u>
Port of Seattle	Yes	No	Yes
METRO	Yes	No	Yes
Department of Game	Yes	Yes	Yes
Fish and Wildlife Service	Yes	No	Yes
National Marine Fisheries Service	Yes	Yes	Yes
Fisheries Research Institute	Yes	No	Yes
Geological Survey	Yes	No	Yes
NOAA-MESA Puget Sound Project	Yes	No	No
URS Company	Yes	No	Yes
Department of Natural Resources	Yes	No	Yes
Corps of Engineers	Yes	No	Yes

Libraries:

University of Washington (Main, Forestry, Fish/Oceanography)
Government Research Assistance - City of Seattle
Municipality of Metropolitan Seattle
King County, Bellevue, and Seattle Public
Environmental Protection Agency
Shapiro and Associates, Inc.
Parametrix, Inc.
Port of Seattle
Corps of Engineers

OTHER AQUATIC RESOURCES

Armstrong, J.W. 1977. The impact of subtidal sewage outfalls on the intertidal macrofauna of several central Puget Sound beaches. Ph.D. thesis. University of Washington, Seattle, Washington, 216 pp.

Source of Information: University of Washington, Fisheries-Oceanography Library

Area of Study: East central Puget Sound - West Point, Alki Point

The macrofauna at West Point and four other beaches in the Seattle area were quantitatively studied to assess the effects of sewage.

Methods and results of this study were as defined in Metro (1977).

The author found no pollution related gradient in species number, diversity or community structure. In general, there was more variation within the habitats he studied at the beaches than among beaches for those same habitats.

Value of Information: 4

Comments: Mainly useful for comparative information; there were no stations within the study area.

OTHER AQUATIC RESOURCES

Armstrong, J.W., R.M. Thom, K.K. Chew, B. Arpke, R. Bohn, Ju. Glock, R. Hieronymus, E. Harlburt, K. Johnson, R. Mayer, Z. Stevens, S. Tattlebach, and P. Waterstrat. 1978. The Impact of the Denny Way Combined Sewer Overflow on the Adjacent Flora and Fauna in Elliott Bay, Puget Sound, Washington. Metro, Seattle, Washington.

Source of Information: Metro

Area of Study: Elliott Bay, Denny Way Outfall

A biological survey of the intertidal and subtidal flora and fauna in the vicinity of the Denny Way combined sewer overflow (CSO) was conducted in April and May, 1977. The purpose of this study was to give a preliminary assessment of the effect of the CSO on the surrounding marine communities.

Intertidally, few species were encountered near the CSO but many individuals of these species were present. The numerically dominant species were the polychaetes Capitella capitata and Nereis vaxillosa, the amphipod Anisogammarus pugettensis and the isopod Gnorimosphaeroma oregonensis. No significant differences were found in the abundances of the four most common epifaunal species among overflow and control sites.

No significant difference was found between the macroalgal communities at the overflow and control sites. However, the abundance of Sargassum muticum was greater near the overflow. Diatom species richness was reduced near the overflow and the microalgal community structure was modified.

The shallowest subtidal sites studies (9m deep) appeared to be more affected by the CSO than the 13 or 24m deep sites. The subtidal area affected, as reflected in the levels of organic material, heavy metals and pesticides in the sediments, as well as the composition of the benthic macrofauna, appeared to be largely localized and to range further south than north. The numerically dominant species at the subtidal sites with the most altered community structure was the polychaete Capitella capitata. This is typical of stressed or polluted environments.

Live cage bioassays with the Pacific oyster, Crassostrea gigas, and the blue mussel, Mytilus edulis, yielded few mortalities. However, there was no large overflows during the course of this study. The condition index of these mollusca was lowest at those sites nearest the CSO.

The transferability of the results of this study to CSO's discharging into fresh waters and recommendations for future studies are discussed.

Value of Information: 5

Comments: Provides a good account of impacts due to storm sewer discharge.

OTHER AQUATIC RESOURCES

Barnhardt, J. April 2, 1976. Declaration of non-significant adverse impact upon the environment SMA #76-7, dredge approximately 10,000 cubic yards adjacent to Pier 23. Lockheed Shipbuilding, Corps of Engineers. 14 pp.

Source of Information: Seattle Municipal Library

Area of Study: Lockheed Pier 23, 2330 S.W. Florida Street, Seattle

This declaration notes no significant impact on existing fauna in the area of the proposed dredging or deterioration of existing wildlife habitat. The U.S. Fish and Wildlife Service reviewed the application and had no objections. No data is given, this is simply a questionnaire on impacts with "yes" and "no" answers.

Value of Information: 3

Comments: None

OTHER AQUATIC RESOURCES
LAND USE
WATER QUALITY

Bortleson, G.C., N.P. Dion, J.B. McConnell, and L.M. Nelson. 1976. Reconnaissance Data on Lakes in Washington, Vol. 2: King and Snohomish Counties. Washington Department of Ecology and U.S. Geological Survey, Water Supply Bulletin #43, Vol. 2, 424 pp.

Source of Information: SAI Library

Area of Study: King and Snohomish Counties

Value of Information: 1

Comments: No lakes drain into Duwamish River; there are summary sheets on lakes in the Green River system. Summary not done.

Campbell, S.A., W.K. Peterson, and J.R. Postel (University of Washington Department of Oceanography). May 1977. Phytoplankton Production and Standing Stock in the Main Basin of Puget Sound. Municipality of Metropolitan Seattle, 132 pages.

Source of Information: Parametrix, Inc.

Area of Study: Central Puget Sound off West Point

This investigation is a part of the Puget Sound Interim Studies sponsored by METRO to measure the effects, if any, of the sewage effluents discharged into the main basin on the waters of Puget Sound. Specifically, the goals of the present study are to ascertain if conditions of phytoplankton standing stock and productivity during 1975 were similar to conditions in the mid-1960's when intensive studies were made or, if differences occur, whether they can be attributed to the activities of METRO.

Observations of physical-chemical conditions and phytoplankton productivity and standing stock were made during the period of high river runoff from 3 April to 13 June, similar to the periods when intensive sampling was carried out in 1966 and 1967. In addition, observations were made during a low runoff period from 1 August to 22 September to determine whether the same processes controlled production at that time as during spring.

In general, the main features of productivity conform with those revealed in previous studies in the area. The major processes controlling phytoplankton production appear to be stability of the water column resulting from high runoff during periods of neap tides and from high solar insolation. These conditions usually appear in late April or early May and result in a series of blooms throughout spring and summer; the number and intensity of the blooms vary with the degree of mixing brought about by runoff, winds, tides, and fluctuations in solar insolation. Only on rare occasions do nutrients (i.e., nitrate) fall to limiting levels and then only for periods lasting from one to three days. The 1975 study shows that processes controlling phytoplankton production during summer are similar to those of spring except that runoff is lower, and thermal stratification apparently plays a larger role in bringing about stability of the water column.

Statistical analyses of conditions during the spring period revealed that 1966 and 1967 were similar, but 1975 differed from both years in lower concentrations of chlorophyll a and higher values of specific productivity. Species composition may be an important reason for these differences; however, this information is not available at this time. The lower values of chlorophyll and higher specific productivity do not appear to be related to increases in nutrients. Indeed, as shown in an accompanying METRO study, present-day concentrations of nutrients are within the normal range of variability observed during the period 1932 to 1975. It is concluded, there-

OTHER AQUATIC RESOURCES

Campbell, S.A., et al. (continued)

fore, that there is no evidence from the present study that the general seasonal patterns and absolute values of phytoplankton standing stock and productivity at Station 1, main basin of Puget Sound, can be related to addition of nutrients by METRO.

Value of Information: 3

Comments: None

Canning, Douglas J., Steven G. Herman, and G. Bradford Shea (Oceanographic Institute of Washington in association with Northwest Environmental Consultants). 21 November 1979. Terminal 107 Environmental Studies - Wildlife Study. Port of Seattle, Planning and Research Department, Final Report, 142 pages.

Source of Information: Port of Seattle, Planning and Research Department

Area of Study: Kellogg Island and Duwamish Waterway

The wildlife study describes investigations carried out from September 1977 through July 1978 with the purpose of evaluating, identifying, and documenting basic information derived from a literature search and field survey, and of evaluating direct and indirect effects of potential development alternatives for Terminal 107 on the wildlife found on the Terminal 107 property and adjacent areas. The study pertains particularly to bird life. Habitat types were identified and wildlife was inventoried. Site visits concentrated on Kellogg Island, with secondary emphasis placed on the Duwamish Waterway and comparisons made at a tertiary level over the Green River Valley-Lake Washington Basin by consulting published and unpublished data summaries, interviewing, and reviewing standard references. Field observations are tabulated, nest sites are mapped on Kellogg Island, and detailed descriptions of bird observations are given. Because of the near absence of mammals in the study area, no analysis of behavior or habitat requirements was made. Development alternatives and their impacts to wildlife at Terminal 107 are tabulated and discussed. Appendices contain field observations and 1977-1978 Audubon Society observations of birds on Kellogg Island and surrounding waters.

Value of Information: 5

Comments: Cursory examination of habitat types and 10-month survey of wildlife populations in the Duwamish Waterway.

OTHER AQUATIC RESOURCES
WATER QUALITY

Dexter, R.N., D.E. Anderson, E.A. Quinlan, W. Hom, and S.P. Pavlov (URS, Inc.). December 1979. Long-term Impacts Induced by Disposal of Contaminated River Sediments in Elliott Bay, Seattle, Washington: Results from Studies Conducted in 1979. U.S. Army Corps of Engineers, 125 pages.

Source of Information: URS, Inc. Library

Area of Study: Elliott Bay

The following points may be summarized from the biological analyses:

- a) Mapping suggests that particular taxa may have higher abundances in and within close proximity to the original sampling grid (i.e., the dredged material disposal site).
- b) Cluster analysis using the abundances for the individual samples (station replicates) and for mean (station replicate) abundances both suggest that samples in close proximity to the dredged material deposit are more similar to each other than to more distant samples.
- c) Spatial autocorrelation analysis revealed that nine taxa exhibited similar differences in abundances at similar distances from the disposal site.
- d) Nonparametric, Wilcoxon two-sample tests revealed significant differences in abundances for nine taxa which were grouped as samples within the grid site versus more distant samples. Most of the taxa tested exhibited greater abundances at the disposal site.
- e) Mapping of physical and chemical parameters showed a similar central tendency and therefore may be interrelated.

Value of Information: 5

Comments: An interim report on benthic organisms and water quality elements. See also Harman and Serwold (1978).

Ebbesmeyer, C.C., and J.M. Helseth (Evans-Hamilton, Inc.). February 1977.
An Analysis of Primary Production Observed during 1966-1975 in Central
Puget Sound, Washington. Final Report, Municipality of Metropolitan
Seattle, 68 pages.

Source of Information: Metro Library

Area of Study: Central Puget Sound - Edwards Point to Blake Island
including one station in Elliott Bay

The objective of this study was to analyze existing observations of primary productivity measurements for evidence of higher than normal growth rate; as a result of effluent discharged from Metro's West Point Sewage Treatment facility. Data utilized for the analysis was gathered during a period from 1966 to 1975 by Metro and the University of Washington Oceanographic Department. Light and dark bottle techniques were used and carbon uptake recorded. Sample stations stretched from Edwards Point on the north to Blake Island in the south. One Elliott Bay Station was included. Some nutrient, salinity, temperature, chlorophyll a data was also included in the University of Washington's sampling. Reported results include a comparison of productivity, chlorophyll a, nutrients, and light penetration with insolation, river discharge, tidal range, and stability. Trends are reported on a month-to-month basis. Yearly variations in primary productivity are also reported for each station including Elliott Bay. Longitudinal variation through the study area is also examined. Their conclusions state that effluent from West Point is a minor factor affecting productivity in Puget Sound due to mixing during semi-diurnal tidal cycles, depth, and circulation patterns.

Value of Information: 3

Comments: None

OTHER AQUATIC RESOURCES
FISHERIES

Environmental Management Division. October 13, 1976. Kellogg Island and the Lower Duwamish Estuary Environmental Conditions. City of Seattle, Department of Community Development, 10 pages plus appendices.

Source of Information: GRA Library (City of Seattle)

Area of Study: Kellogg Island and the Lower Duwamish Estuary .

This report, prepared for the City Council, covers the existing environmental conditions and resources of the island including vegetation, Pacific Flyway (feeding and resting areas for migratory fowl), fisheries, species observed on the island, history of human intrusion, log storage and moorage, dredge spoil, and potential archaeological conditions.

The report is based on several field trips to the island by the Environmental Management Division, review of other scientific information, and intended as a summary of conditions on Kellogg Island.

Value of Information: 5

Comments: Good information on waterfowl species and fish production.

OTHER AQUATIC RESOURCES
WATER QUALITY

Harman, R.A., and J.C. Serwold, and Marine Technicians. September 1974.
Baseline Study of Sediment Provinces and Biotopes of Elliott Bay and
Vicinity, Washington. Shoreline Community College, Marine Technical
Report No. 2, 57 pages.

Source of Information: University of Washington, Fisheries-Oceanography
Library

Area of Study: Elliott Bay and adjacent waters

The suspended load from the Duwamish River is deposited on the eastern portion of Elliott Bay while its bedload is deposited on the western side. Distribution of diatoms, foraminifers, pelecypods, gastropods and specimens from polychaete worm families are influenced by this suspended load distribution. Water stratification and advection are more important in accounting for the distribution of river-born particles than vertical sinking since most debris does not accumulate below the 50 fathom contour despite close proximity to the river mouth. The distribution of Foraminifera and diatoms as compared to the macrofauna also appear to respond to water stratification in that their distribution is controlled more by water depth. Although the macrofauna are influenced by river sedimentation, their distribution over greater depth ranges also suggest the importance of shelf displacement or vertical transport of food by plankton or nekton. The western portion of Elliott Bay and the shelves outside of Elliott Bay have more diverse faunas. Shelf displacement appears to affect the numbers of benthic organisms in the deep areas of Puget Sound. The former dump site off Fourmile Rock has reduced the macrofauna density but has not noticeably altered the adjacent macrofauna sites where dumped debris has dispersed.

Value of Information: 5

Comments: None

OTHER AQUATIC RESOURCES
WATER QUALITY

Harman, R.A., J.C. Serwold, R.C. Sylvester, and Marine Technicians (Shoreline Community College). May 1977. Distribution of Subtidal Benthic Organisms, Sediments, and Habitats Near the West Point Outfall and Partial Analysis of Data. Final Report, Metro, Puget Sound Interim Studies.

Source of Information: Fisheries-Oceanography literature, University of Washington

Area of Study: West Point Outfall

Seattle's West Point outfall effluent does not significantly influence the bottom sediment or benthic macrofauna. Benthic foraminifera, polychaetes, and pelecypods are abundant at intermediate depths. Wood and rock debris from dredging old sludge, log mooring, storm sewer overflows, and river runoff increase the variability of the macrofaunal data and thus make it difficult to assess the influence of the outfall on the macrofauna. The habitats of Shilshole Bay seem to be under less environmental stress than those of Elliott Bay. Regionally, the study area, as well as Elliott Bay, display major differences with the more distant estuaries of Dyes Inlet, Port Orchard, Port Madison, and Liberty Bay. Three depth zones are identified: a shallow zone (0-15 fathoms), an intermediate zone (15-50 fathoms), and a deep zone (50-100+ fathoms). Materials from shallow areas, dispersed into the deeper habitats, appear to account for increased species richness in the deeper areas.

Value of Information: 3

Comments: None

OTHER AQUATIC RESOURCES

Harman, R.A., and J.C. Serwold (Shoreline Community College). June 1978. Recolonization of Benthic Macrofauna over a Deep-Water Disposal Site, Appendix F; on microfiche in Evaluative Summary Report. U.S. Army Corps of Engineers, Dredged Material Research Program, Waterways Experiment Station. Tech. Report D-77-24. (8 microfiche)

Source of Information: Corps of Engineers Library

Area of Study: Elliott Bay

Benthic data and results of the pilot study conducted during November and December 1978 on the effect of open-water disposal of contaminated dredge material from the Duwamish River is discussed. Benthic samples from Elliott Bay and the Duwamish River were taken, sediment characteristics described, and important gastropods, pelecypods (bivalves) and polychaetes identified. Individual species found during the course of the investigation at the various sites were analyzed in detail. This appendix also includes discussion of the ecology of Puget Sound and its fauna. The major finding is that 9 months after disposal, the structure of the biological community at the disposal site had not returned to its predisposal composition, and the authors suggest that deep-water, protected habitats recover at a slow rate when disturbed. The benthic organisms were significantly depressed in the central stations of the disposal site, but values for number of species, density, and biomass showed these animals were more abundant at the margins of the disposal site than before. More animals were found at the corners of the disposal site at 9 months after disposal than at either reference site, and a number of benthic species were actively recolonizing the dredged material mounds, even though density and biomass values remained low.

It should be noted that the reference sites and the disposal sites were not easily comparable due to the relative size of the disposal site compared to reference sites, the inadequate predisposal data, and the overriding influence of the Duwamish River on the disposal site. Furthermore, initial decreases in species at the disposal site were matched by decreases at the reference sites, and there was evidence that seasonal trends may have played a role in the changes noted.

Value of Information: 5

Comments: See also Dexter, et al., 1979.

OTHER AQUATIC RESOURCES
WATER QUALITY
FISHERIES

Hughes, J.R., W.E. Ames, D.A. Misitano, and G.F. Slusser (National Marine Fisheries Service). May 1978. Aquatic Disposal Field Investigations Duwamish Waterway Disposal Site, Puget Sound, Washington. Appendix A: Effects of Dredged Material Disposal on Demersal Fish and Shellfish in Elliott Bay, Seattle, Washington. U.S. Army Corps of Engineers, Dredged Material Research Programs, Waterways Experiment Station. Tech. Report D-77-24, 62 pages plus 42-page appendix.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

The purpose of this study done from November 1975 to December 1976 was to determine the effects of open-water disposal of contaminated dredged material from the Duwamish River on the indigenous demersal fish and decapod shellfish at the Elliott Bay disposal site. The disposal site and two reference sites were sampled by a Marineovich trawl prior to, during, and 1 week and 1, 3, 6, and 9 months after disposal. It was determined that the volume of dredged material released at the disposal site did not have a lasting effect on the composition and abundance of the demersal fish and shellfish at the disposal site. Detailed information is given on water quality and organisms sampled. Appendix A details the total catch of demersal vertebrates and invertebrates by species and individual trawl at each sampling station for each sampling period. Data was difficult to interpret as the short time period of the study made it difficult to determine if differences noted were attributable to the effects of dredged material disposal rather than natural population fluctuations caused by seasonal migrations for spawning, feeding, etc. Interpretation was further complicated by the fact that the three test sites were not comparable with respect to bottom sediments, proximity to a source of fresh water, and indigenous species present. There were, in addition, problems with trawling, and the time of disposal coincided with the flood stage of the Duwamish when large volumes of sediment were being carried naturally into Elliott Bay.

Value of Information: 5

Comments: None

OTHER AQUATIC RESOURCES

Jermann, J.V., T.H. Lorenz, R.S. Thomas (Office of Public Archaeology, Institute for Environmental Studies, University of Washington). March 1977. Continued Archaeological Testing at the Duwamish No. 1 Site (45K123). Port of Seattle, Reconnaissance Report No. 11, 103 pages.

Source of Information: Northwest Collection, Suzzallo Library, University of Washington

Area of Study: Lower Duwamish, Terminal 107 Site, Kellogg Island

In the fall of 1975, an aboriginal shell midden site on the Terminal 107 property was located, leading to recommendation that the site be archaeologically evaluated prior to any Port development. A three-phase testing program was used to recover data: 1) dispersed auger coring, 2) systematic auger coring and surface collecting, and 3) subsurface test excavation. Field derived data was analyzed and available archival materials synthesized. Resultant recommendations were that the Duwamish No. 1 site be nominated to the National Register of Historic Places, that full-scale archaeological investigations be conducted at the site prior to any development activity, and that tightened security measures be instituted to prevent unsupervised exploration of the site by the general public.

This report documents the natural and cultural history of the area and describes the archaeological assessment and monitoring. Some 468 samples of cultural remains were recovered and categorized. Bone artifacts included domestic cow, horned grebe, pochard, salmon and flounder, as well as domestic dog or cat remains. Shell comprised the bulk of the cultural deposits and are categorized as edible blue mussel (Mytilus edulis), butter clam (Saxidomus nuttalli), bent-nose clam (Macoma spp.), limpet (Hipponix tumen), horse clam (Schizothaerus spp.), native oyster (Ostrea lurida), two species of snail (Nassarius mendicus and Littorina scutulata), and barnacle (Balanus spp.). Dating techniques indicated that the site was occupied as much as 14 centuries ago.

Value of Information: 5

Comments: Report contains excellent archaeological information. See also page A-48.

OTHER AQUATIC RESOURCES

Larrison, E.J. 1952. Field Guide to Birds of Puget Sound. Seattle Audubon Society, 112 pages.

Source of Information: Forestry Library, University of Washington

Area of Study: Puget Sound

Value of Information: 1

Comments: This is a general guide to birds of the Puget Sound area, useful as a reference in identification of birds observed.

OTHER AQUATIC RESOURCES
LAND USE

Lorenz, T.H., G.R. Spearman, J.V. Jermann (Office of Public Archaeology, Institute for Environmental Studies, University of Washington). May 1976. Archaeological Testing at the Duwamish No. 1 Site, King County, Washington. Port of Seattle, Reconnaissance Report No. 8, 70 pages.

Source of Information: Northwest Collection, Suzallo Library, University of Washington

Area of Study: Duwamish

This study was funded after an aboriginal shell midden site on the Terminal 107 property was located in the fall of 1975. Following descriptions of the environmental setting and ethnohistory of the Duwamish No. 1 Site, formally designated in the State's Archaeological Site Survey Records as 45-K1-23, project strategy and tactics are discussed, followed by artifact analysis of samples obtained from an archaeological assessment of the site. The site was assessed in three phases: 1) placement of a scattered series of soil auger cones to determine the site's horizontal limits, 2) systematic coring and surface collecting of the Phase 1-delineated site area, and 3) test excavation of the midden deposit. Stratigraphic profiles are given of test excavations, as well as detailed information on the site inventory, which includes bone and shell fragments from a variety of species. A listing of bird species observed in the immediate vicinity is also provided from the Seattle Audubon Society. It is noted that the site is most likely a manifestation of Duwamish tribal culture.

Value of Information: 5

Comments: See also pages A-48 and D-18.

OTHER AQUATIC RESOURCES

McGreevy, R. 1973. Seattle Shoreline Environment. City of Seattle, Department of Community Development and Washington Sea Grant Program, 41 pp.

Source of Information: Lake Hills Library, Bellevue

Area of Study: Seattle shoreline

Specific areas of the Seattle Shoreline are described with black and white photographs of the areas included. Maps, tables, and drawings are also used to detail shoreline-related topics, including environments, fish, aquatic animal life, commercial harvesting and sports fishery, underwater recreation areas, plant life and marsh lands, wildlife, waterfowl, geology and scientific and educational areas.

The description of the Duwamish Waterway notes the resident and migratory fish populations, and portions of Kellogg Island are the only notable wildlife habitat, serving as a feeding and resting ground for waterfowl and waterbirds. Detailed tables note waterbird abundance in winter, waterfowl and their food plants, and abundance of migrants. Marine shellfish, freshwater shellfish, common marine organisms, and common freshwater organisms are described as to habitat, and drawings show marine life found in typical tidelands.

Value of Information: 2

Comments: Supplement to earlier Seattle Shoreline Inventory published by Office of Environmental Management in compliance with Washington State Shoreline Management Act of 1971.

OTHER AQUATIC RESOURCES
WATER QUALITY

Metro. August 1977. Studies of Intertidal Biota at Five Seattle Beaches.
Final Reports.

Source of Information: Fisheries-Oceanography, University of Washington

Area of Study: East Central Puget Sound - West Point, Alki Point

The results of three separate studies on the impact of Seattle's wastewater discharge upon the intertidal fauna and flora of central Puget Sound are contained in the report, and two of the studies contain information related to marine benthic communities and macroflora. Analyses of data from surveys conducted in 1971, 1973, and 1975 of the intertidal macrofauna and macroflora near the West Point Sewage Treatment Plant show significant increases in species composition, abundance, richness, and diversity over this four-year period. Biological trends are interpreted in light of meteorological conditions, sewage discharge, and biotic interactions. From July 1974 through April 1976, the intertidal macrofauna were studied at four Seattle-area beaches adjacent to subtidal sewage outfalls and at one beach without an outfall. Attempts were made to find existing community differences between the beaches by several methods: species lists, relative abundances of various taxa, diversity indices, species richness curves, and site-classification techniques. None of these methods indicated that the intertidal macrofaunal communities at any of the beaches were measurably stressed by sewage. Results of surveys for benthic algae are also summarized (see also Thom, 1978; Thom, Armstrong, Staude, Chew, and Norris, 1976; Syesis 9:267-775, for additional reviews of these data). Seasonality in number of species within algal divisions and total number of algal species was seen. Authors also noted marked seasonal changes in the composition of green, red, and brown algae.

Value of Information: 4

Comments: Three reports are combined in this volume. Interim reports may be consulted for additional information.

OTHER AQUATIC RESOURCES
WATER QUALITY

Metro. January 1978. Areawide Water Quality Plan Pursuant to Section 208 of P.L. 92-500, King County, Washington, Cedar-Green River Basins. 111 pages plus appendices.

Source of Information: Metro

Area of Study: Cedar-Green River Basins within King County

The plan presents an assessment of the priority water quality problems within that portion of the Cedar-Green River Basins lying within King County, develops solutions to these problems, and identifies management agencies to implement the recommended solutions. Water quality problem areas are identified as erosion/sedimentation, fecal pollution, weeds and algae, toxicants, sewage facility needs, and continuing water quality planning.

Value of Information: 1

Comments: Report limited to water quality and aquatic plants - no information on wildlife or aquatic fauna.

OTHER AQUATIC RESOURCES
FISHERIES

Pacific Northwest River Basins Commission. March 1970. Comprehensive Study of Water and Related Resources, Puget Sound and Adjacent Waters, State of Washington, Appendix XI, Fish and Wildlife. Fish and Wildlife Technical Committee, Puget Sound Task Force, Section 9, 35 pages.

Source of Information: SAI Library

Area of Study: Puget Sound and adjacent waters

The purpose of the appendix is to describe the uses of the Puget Sound area by fish and wildlife, define the locations of greatest importance and overall utilization, and present a plan to conserve and enhance fish and wildlife that will meet short and long-range needs for these valuable natural resources. This is one of 15 appendices providing supporting data for the Comprehensive Water Resource Study of Puget Sound. Study scope involves the present status and future needs for fish and wildlife and means to satisfy these needs to meet anticipated demands. Data review was augmented by field investigations timed to coincide with seasonal life cycles and management cropping patterns of various species, and resource requirements over a 50-year period, including individual needs within the 11 river basins of the study, were defined. Detailed information is given in the Cedar-Green River Basins section for present status, future needs, and means to satisfy needs for anadromous fish, marine fish, shellfish, game fish, and wildlife.

Value of Information: 2

Comments: Very little detailed data; more on fisheries. See also pages A-19 and E-8.

OTHER AQUATIC RESOURCES

Parametrix, Inc. April 1976. Environmental studies and assessment of impacts of possible developments, Southeast Harbor area - Section D. Marine life: biological survey and assessment of impact of alternative redevelopments. Port of Seattle, 79 pp. in Section D.

Source of Information: Parametrix, Inc.

Area of Study: Southeast Elliott Bay, East Waterway, from Terminal 25 north to Terminal 46, Piers 90-91

A biological survey of the Southeast Harbor and Piers 90-91 areas was conducted to identify the invertebrate and fish populations that might be affected by redevelopment alternatives being considered for these areas. The survey included sampling of fish by gill nets, sampling of soft bottom benthos, diver inspection of piling and riprap, as well as a shrimp pot survey. A survey was made of all available literature describing the biota of Elliott Bay and the Duwamish Estuary. All organisms collected were identified and catalogued, and pertinent information is detailed and tabulated in this report. The only significant impact the various redevelopment configurations can be expected to have on the estuarine biota are changes in the amount of available habitat.

Value of Information: 5

Comments: Other topics reported include sediments, current regime, water quality, noise, traffic, and air quality. See also page A-53.

OTHER AQUATIC RESOURCES

Phillips, R.C. (University of Washington). 1972. Ecological Life History of Zostera mariana L. (Eelgrass) in Puget Sound, Washinton. Ph.D. Dissertation, University of Washington Press, 154 pages.

Source of Information: University of Washington Library - Natural Science

Area of Study: Puget Sound

This thesis looks at seasonal growth, reproductive cycle, and habitat range of eelgrass. Extensive field studies including transects and live plant transplants were performed in 100 sampling locations. Laboratory observations of plants under culture were also undertaken. Eelgrass occurred on the east and west shores of Puget Sound. Most luxuriant growth was found in the salinity range of 27 to 34 ppm where currents were moderately strong (3 knots). Optimum temperature range was from 7.5°C to 12.5°C. Eelgrass extended from mean lower low water to -22 feet over most of Puget Sound, probably limited in deeper water due to limiting light penetration.

Value of Information: 2

Comments: Principal subject is eelgrass life history and habitat range in Puget Sound. One sample station at Alki Point is near Elliott Bay.

OTHER AQUATIC RESOURCES

Salo, L.J. September 1975. A Baseline Survey of Significant Marine Birds in Washington State. Washington State Departments of Game and Ecology, Coastal Zone Environmental Studies Report No. 1, 417 pages.

Source of Information: U.S. Army Corps of Engineers Library

Area of Study: State of Washington

In 1974-75 as part of the Baseline Study Program, the Washington Department of Ecology financed a study of the status of 73 species of sea-birds and shorebirds considered "significant biological resources" of the state. The report summarizes all available published and unpublished information, emphasizing the distribution of each species in the coastal habitat. A set of maps locates observations of nesting, congregations of migrating or non-breeding resident birds numbering more than 5,000 birds, and other non-breeding observations. Species are described as to habitat, breeding, migrating, and feeding habits, followed by generalized observation maps. There is no distinct information for the Duwamish Waterway or Elliott Bay, although maps indicate species that might be observed in those areas.

Value of Information: 1

Comments: Data from the study has been computerized and stored. Report is a general summary of the gathered information.

OTHER AQUATIC RESOURCES
WATER QUALITY

Santos, J.F., and J.D. Stoner. 1972. Physical, Chemical, and Biological Aspects of the Duwamish River Estuary, King County, Washington, 1963-1967. Geological Survey Water Supply Paper, 1873-C, 74 pages.

Source of Information: University of Washington Library - Natural Sciences

Area of Study: Lower Duwamish

Summarizes previous research regarding phytoplankton blooms in relation to physical factors in the estuary.

Value of Information: 4

Comments: See also page B-66.

OTHER AQUATIC RESOURCES

Southern Elliott Bay Benthic Study. Seattle Harbor Navigation
File F-3c(1), 6 pages.

Source of Information: U.S. Fish & Wildlife Service, Olympia

Area of Study: Southern Elliott Bay

These rough notes taken from the Duwamish file of the U.S. Fish and Wildlife Services in Olympia (Nancy Nelson) document benthic invertebrates sampled. The notes are incomplete, no author or date is given. There are descriptions of several species of worms and some shellfish.

Value of Information: 2

Comments: None.

OTHER AQUATIC RESOURCES
WATER QUALITY

Stout, V.F., and L.G. Lewis (Northwest and Alaska Fisheries Center). November 1977. Aquatic Disposal Field Investigations, Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix B: Role of Disposal of PCB-Contaminated Sediment in the Accumulation of PCB's by Marine Animals. U.S. Army Corps of Engineers, Dredged Material Research Program, Waterways Experiment Station, Tech. Report D-77-24, 27 pages plus 13 pages of tables.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

The purpose of this study was to determine whether PCB's in dredged material were transferred to marine organisms either during or after an open water disposal operation. The PCB content of indigenous animals and animals caged at the site was determined. The data indicated that the dredged material disposal operation resulted in no obvious or statistically significant increases in the PCB levels of the marine organisms studied. Sampling was conducted before, during, and after exposure, and results are tabulated for English sole (Parophrys vetulus), Alaska pink shrimp (Pandalus borealis), spot shrimp (Pandalus platyceros), sea cucumbers (Parastichopus californicus), and mussels (Mytilus edulis).

Value of Information: 3

Comments: See also page B-51.

OTHER AQUATIC RESOURCES
WATER QUALITY

Tatem, H.E., and J.E. Johnson. June 1978. Aquatic Disposal Field Investigations Duwamish Waterway Disposal Site, Puget Sound, Washington, Evaluative Summary. U.S. Army Corps of Engineers, Dredged Material Research Program, Waterways Experiment Station. Tech. Report D-77-24, 77 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

The effect of open-water disposal of 114,250 m³ of contaminated material from the Duwamish River on an Elliott Bay disposal site was studied to determine the physical, chemical, and biological effects of open water disposal of the dredged material. A pilot survey, conducted in November and December 1975, was followed by a full-scale field assessment program. Chemical analysis of sediment, water, and animal tissue were completed, including analysis for metals such as mercury and organic contaminants such as polychlorinated biphenyls. Demersal fish and shellfish were sampled throughout the study, and benthic samples were collected from the disposal and reference sites. The data revealed no adverse effect from the disposal of material on demersal fish and shellfish, and there was no significant accumulation of mercury, chromium, or PCB's by a variety of estuarine animals exposed to the dredged material. The primary impact was physical and was on the benthic fauna at the center of the disposal site, where small benthic invertebrates were harmed physically. These studies are detailed in separate Appendices A through G, which deal with specific units of the project, and are summarized as a group in this report.

Value of Information: 5

Comments: Report summarizes studies reported separately in Appendices A through G. See also page B-53.

OTHER AQUATIC RESOURCES
WATER QUALITY

Teeny, F.M. and A.S. Hall (Northwest and Alaska Fisheries Center). November 1977. Aquatic Disposal Field Investigations Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix C: Effects of Dredged Material Disposal on the Concentration of Mercury and Chromium in Several Species of Marine Animals. U.S. Army Corps of Engineers, Dredged Material Research Program, Waterways Experiment Station. Tech. Report D-77-24, 22 pages.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Elliott Bay

The purpose of this study was to determine the effect of open water disposal of dredged material from the Duwamish Waterway into Elliott Bay on uptake of mercury and chromium by spot shrimp, sea cucumber, mussel, English sole, and Alaska and Oregon pink shrimp. Organisms were collected over a period of nine months from two environmentally similar sites in Elliott Bay, a disposal site, and a control site. Tissue analysis of whole organisms for mercury and chromium revealed no significant differences between the two sites before or after the disposal operation.

Value of Information: 3

Comments: See also page B-54.

Thom, R.M. 1978. The composition, growth, seasonal periodicity and habitats of benthic algae on the eastern shore of central Puget Sound, with special reference to sewage pollution. Ph.D. Thesis. University of Washington, Seattle, Washington, 237 pp.

Source of Information: University of Washington, Fisheries-Oceanography Library

Area of Study: East central Puget Sound - West Point, Alki Point, and Denny Way Combined Sewer Overflow

The author studied the composition, richness, diversity, cover, and succession of benthic macro and microalgal communities and the growth of selected species seasonally for two years at five beaches on the eastern shore of central Puget Sound, and less intensively at the site of the Denny Way sewage overflow discharge.

The objectives of the study were to test whether sewage discharged near the beaches had any effect on the benthic flora, gather information on the seasonal aspects of the algal assemblages in the area, and explore causal relationships between environmental factors and algal community structure.

The method was a descriptive approach with a multivariate community analysis.

Substantial seasonal fluctuations in numbers of species, species composition, diversity and cover were evident, and were explained by fluctuations in temperatures, light and tidal characteristics. The richest complement of species and greatest cover occurred in spring and summer when light and temperature were highest. Brown algae were most abundant in spring, green algae in summer, and red algae in autumn. A total of 157 macroscopic benthic algal species were noted during the study.

Differences among beaches were seen in algal species richness and diversity. These differences appeared to be related to substrata composition rather than to sewage flows at the beaches. However, at the most acutely polluted site, which was near the Denny Way outfall, macro and microalgal richness and community composition were significantly altered.

The author concluded that the relatively large variations in physical factors by season and lack of suitable habitat in the study area, favored ephemeral species, while competition-adapted and slow-growing forms were usually excluded.

Value of Information: 5

Comments: None

OTHER AQUATIC RESOURCES

Thom, R.M., K.K. Chew, and J.Q. Word. 1979. Abundance, biomass, and trophic structure of the subtidal infaunal communities of the eastern side of central Puget Sound. Metro, Seattle, Washington.

Source of Information: URS, Inc. Library

Area of Study: East central Puget Sound, West Point

Reports the results of a community analysis of infauna at 100 sites adjacent to West Point. An index of infaunal trophic structure was used to evaluate the impacts of the West Point sewage outfall on the benthic community.

The most significant influence of the effluent was to enrich the benthic community, particularly by increasing the abundance of filter-feeding organisms.

Value of Information: 3

Comments: Control stations were sampled off Magnolia Bluff and Alki Point.

OTHER AQUATIC RESOURCES
WATER QUALITY

Tilley, L.J., and W.A. Dawson. 1971. Plant nutrients and the estuary mechanism in the Duwamish River estuary, Seattle, Washington. U.S. Geological Survey, Professional Paper, 750-C, pages C185-C191.

Source of Information: University of Washington Library - Natural Sciences

Area of Study: Lower Duwamish (river km 1.9-21.1)

Estuaries are traps which can be fertilized by three different sources: 1) salt wedge; 2) man-introduced nutrients; and 3) nutrients leached from the soil. The nutrient sampling program which lasted from March 1967 to July 1968 provided the data to evaluate the input from the three sources. Sampling occurred between river km 1.9 and 21.1. Results show that a nearly twofold increase in concentration of nutrients occurs in the salt wedge. The increase consists of nutrients transferred from the outflowing river water in amounts which barely affect river-water concentrations.

Value of Information: 4

Comments: This pertains mostly to water quality. See also page B-68.

OTHER AQUATIC RESOURCES

Tilley, L.J., and W.L. Haushild. 1975a. Net primary productivity of periphytic algae in the intertidal zone, Duwamish River Estuary, Washington. U.S. Geological Survey, Jour. Research May-June, Vol. 3(3):253-259.

Source of Information: University of Washington Library - Natural Sciences

Area of Study: Lower Duwamish (river km 1.9 to 10.5)

This paper is part of the comprehensive study to determine causes and effects of dissolved oxygen variation in the Duwamish estuary. In this study, periphyton was collected on glass microscopic slides and chlorophyll a was used to estimate algal productivity. At three sampling stations (river km 1.9, 7.7, and 10.5) periphyton accumulation was measured in 1, 2, 3, and 4 week intervals during the summer and fall, 1970. The glass substrates were attached along vertical staffs to provide an exposure series related to tidal variation.

Low primary productivity of intertidal attached algae on substrates was observed and attributed to out-of-water dessication; part of the observed variability in accumulation of periphytic algae was attributed to time out-of-water exposures. The low net primary productivity of periphyton in the intertidal zone could not account for the decreasing dissolved oxygen levels in the estuary. Phytoplankton, which has a higher productivity, probably plays a major role in determining dissolved oxygen levels.

Value of Information: 4

Comments: Provides limited information on primary productivity of periphytic algae and professes their minor contribution to estuarine productivity in the Duwamish.

OTHER AQUATIC RESOURCES
WATER QUALITY

Tilley, L.J., and W.L. Haushild. 1975b. Use of Productivity of Periphyton to Estimate Water Quality. USGS, Water Pollution Control Federation Journal, Vol. 47(8):2157-2171, August.

Source of Information: Engineering Library, University of Washington

Area of Study: Duwamish-Green River to river km 98.6.

Net primary productivity of the algal fraction was used to evaluate selected water quality parameters in the Duwamish-Green River. Chlorophyll a concentration was used as an estimate of the algal biomass in periphyton accumulated on artificial substrates (glass microscopic slides). Sampling was carried out from July through October 1969 at river km 98.6, 58.1, 36.8, 12.6, and 10.5. Periphyton growth was most rapid in summer and early fall. Average net primary productivity increased five-fold in the downstream direction, varied directly with increases in selected nutrients, and varied inversely with stream gradient. Algae may not contribute to low dissolved oxygen levels in the dredged part of the Duwamish River estuary because, while periphyton is undergoing a high rate of accumulation, stream flow and scour is low.

Value of Information: 4

Comments: None

U.S. Army Corps of Engineers. Aquatic disposal field investigations, Duwamish waterway disposal site, Puget Sound, Washington, Appendix G: Benthic community structural changes resulting from dredged material disposal, Elliott Bay Disposal Site. Dredged Material Research Program, Waterways Experiment Station, Tech. Report D-77-24.

Source of Information: Corps of Engineers

Area of Study: Elliott Bay

This report provides additional numerical analysis of the data from the benthic work of the pilot study conducted in November and December 1975 on the effect of open-water disposal of contaminated dredge material from the Duwamish River. The major groups of benthic organisms involved were gastropods, bivalves, errant polychaetes, sedentary polychaetes, and miscellaneous species. The data clearly show the effects of disposal on the central disposal stations while revealing the lack of adverse effects at the margins of the disposal site. Data from the central stations show that even these stations suffered no permanent damage since the mean number of species present climbed from a low of 3 to 25 at 9 months after disposal. Mean density and biomass remained fairly low, however, at 9 months for the central stations. The investigation suffered from the limited time span available, differences in the disposal and reference sites, and lack of sufficient predisposal data.

Value of Information: 4

Comments: Not available for review, summary is made from information given in Evaluative Summary of project (see Tatem and Johnson).

OTHER AQUATIC RESOURCES
WATER QUALITY
FISHERIES

U.S. Army Corps of Engineers. June 1979. Seattle Harbor Navigation Project - Operation and Maintenance. Final Supplement to Environmental Impact Statement. 124 pages plus appendices. U.S. Army Corps of Engineers, Seattle District.

Source of Information: U.S. Army Corps of Engineers

Area of Study: Seattle Harbor

Environmental impacts resulting from proposed continued maintenance dredging of the Seattle Harbor Navigation project are assessed for water quality, marine biology, social and economic impact, and adverse environmental impacts. Benthic communities in the immediate dredging area are expected to be reduced temporarily, while communities in the proposed disposal areas which will be converted from open water environments to upland areas will be lost. Communities are expected to be reduced or temporarily lost in open water disposal areas.

Benthic organisms inhabiting the Duwamish Waterway are listed in Table 8 on page 32. Biological systems are described, including benthic organisms, fish, wildlife, birds, and marine mammals. Wildlife habitat includes Kellogg Island, which is also utilized during fall and winter by migratory and wintering birds. Bird observations are tabulated in Table 11, page 36. Sightings of stellar sea lions and harbor seals in the East and West Waterways around Harbor Island are also noted.

Figure 11, page 39, illustrates and lists both flora and fauna found in Elliott Bay. Bay communities are described as to benthic organisms, fish, birds, and marine mammals. Marine biota growing on pilings and riprap in the Southeast Harbor of Elliott Bay is tabulated, and it is noted that there are no known threatened or endangered species in either the dredging or disposal site.

Value of Information: 5

Comments: None.

OTHER AQUATIC RESOURCES
FISHERIES

U.S. Fish and Wildlife Service. November 1974. Draft Report - Effects of proposed navigation improvements on the East, West, and Duwamish Waterways on fish and wildlife resources. 25 pages.

Source of Information: U.S. Fish and Wildlife Service, Olympia

Area of Study: East, West, and Duwamish Waterways

Presents USFWS interpretation of possible impacts and recommendations regarding waterway development on the Duwamish. Conclusions are as follows:

"The high probability of serious impacts to the fishery resources caused by this project, as proposed, necessitates studies to develop means to overcome expected low DO values in the saltwater wedge. The settling basins, in addition to destroying habitat for wildlife, could have detrimental effects on the fishery resources and should be excluded from the project. Due to the decreasing amount of tidelands in the Duwamish Water, disposal sites II, III, and the shallow water areas around site VII should not be filled."

Value of Information: 5

Comments: None.

OTHER AQUATIC RESOURCES

Wahl, T.R., and D.R. Paulsen. 1971. A Guide to Bird Finding in Washington.
American Ornithologists Union.

Source of Information: Suzallo Library, University of Washington

Area of Study: State of Washington

This guide to bird finding provides a listing of birds to be seen in the state, indicating their seasonality and habitat types in which they can be observed. Individual site descriptions are detailed for specific viewing areas throughout the state, including information on elevation, life zone, habitat types, how to reach the area, and a generalized accounting of birds to be seen. Seattle is covered as a viewing site with observation points at the University of Washington, Green Lake, Golden Gardens, Alki Beach Park, and Lincoln Park covered. There is no specific information on either the Duwamish Waterway or Elliott Bay.

Value of Information: 1

Comments: None

OTHER AQUATIC RESOURCES
WATER QUALITY

Welch, E.B. 1969. Factors initiating phytoplankton blooms and resulting effects on dissolved oxygen in Duwamish River estuary, Seattle, Washington. Geological Survey Water Supply Paper, 1873-A, 62 pages.

Source of Information: University of Washington Library - Main

Area of Study: Lower Duwamish

Phytoplankton productivity, standing stock, and related environmental factors were studied during 1964-66 in the Duwamish River estuary at Seattle, WA, to ascertain the factors that affect phytoplankton growth in the estuary. The factors that control the concentration of dissolved oxygen were also evaluated because of the importance of dissolved oxygen to the salmonid populations that migrate through the estuary. Phytoplankton blooms, primarily of diatoms, occurred in the lower estuary during August 1965 and 1966. No bloom occurred during 1964, but the presence of oxygen-supersaturated surface water in August 1963 indicates that a bloom did occur then.

Nutrients probably were not the primary factor controlling the timing of phytoplankton blooms. Ammonia and phosphate concentrations increased significantly downstream from METRO's Renton Treatment Plant outfall after the plant began operation in June 1965, and concentrations of nitrogen and phosphorus were relatively high before operation of the Renton Treatment Plant and during nonbloom periods. The consistent coincidence of blooms with minimum freshwater discharge and tidal exchange during August throughout the study period indicates that bloom timing probably was controlled mostly by hydrographic factors that determine retention time and stability of the surface water layer. This control was demonstrated in part by a highly significant correlation of gross productivity with retention time (as indicated by freshwater discharge) and vertical stability (as indicated by the difference between mean surface and mean bottom temperatures). The failure of a bloom to develop in 1964 is related to a minimum freshwater discharge that was much greater than normal during that summer. Hydrographic factors are apparently important because, as shown by studies of other estuarine environments by other workers, phytoplankton production increases when the zone of vertical turbulent mixing is not markedly deeper than the compensation depth.

The maximum BOD (biochemical oxygen demand) in the bottom wedge occurs in the same section of the estuary and at the same time as the maximum phytoplankton biomass (as indicated by chlorophyll a) and minimum DO (dissolved oxygen). Respiration and decomposition of phytoplankton cells is clearly an important contributor of BOD. Increases in the biomass and resultant BOD of blooms because of increased effluent nutrients presumably would further decrease the concentration of DO. This possible effect of effluent nutrients was evaluated by laboratory bioassays and by a comparison of mean annual biomasses in the estuary. A green algal population in vitro did increase in response to added effluent nutrients; however, the available field data suggest that a 46% increase in effluent discharge between 1965 and 1966 did not increase the estuary's phytoplankton biomass significantly.

Value of Information: 4

Comments: See also page B-73.

OTHER AQUATIC RESOURCES
WATER QUALITY

Welch, E.B. October 1968. Phytoplankton and related water quality conditions in an enriched estuary. USGS, Water Pollution Control Federation Journal, 40(10):1711-1727.

Source of Information: University of Washington, Fisheries-Oceanography Library

Area of Study: Lower Duwamish (river km 21.1)

The purpose of this study is to evaluate the influence of nutrient additives from the effluent of the Renton Treatment Plant on phytoplankton standing stock and productivity in the Duwamish estuary. Sampling for productivity occurred monthly at 4 stations (river km 21.1, 12.6, 7.7, and 1.9). During 1965, sampling was conducted during both high and low tide. In 1964, samples were collected at mid-tide stage. Light- and dark-bottle oxygen technique was used to measure productivity.

The results indicate the relationship between phytoplankton productivity (blooms) and nutrient concentrations. It was concluded that bloom timing was related to hydrographic conditions. Peak phytoplankton activity occurred during periods when retention and stability of water were probably maximum, as indicated by freshwater discharge and tidal-prism thickness. During the year when phytoplankton activity was least, the minimum freshwater discharge was greatest, and the minimum persisted for a shorter period.

Value of Information: 4

Comments: Regarding productivity, the primary usefulness of this paper is the discussion of factors which are probably most important in phytoplankton blooms.

Welch, E.B., R.M. Emery (Department of Civil Engineering, University of Washington), R.I. Matsuda (Municipality of Metropolitan Seattle), and W.A. Dawson (U.S. Geological Survey). 1972. The relationship of periphytic and planktonic algal growth in an estuary to hydrographic factors. Limnology and Oceanography, 17(5):731-737, September.

Source of Information: University of Washington, Fisheries-Oceanography Library

Area of Study: Duwamish estuary up to river km 12.6

The seasonal periodicity of periphyton growth in the Duwamish estuary (Washington) is compared with that of phytoplankton and lends support to a previous conclusion that hydrographic conditions determine the timing of phytoplankton blooms despite high concentrations of dissolved nitrogen and phosphorous. During the sampling period, from 1965 to 1967, accumulation of periphyton on substrates increased in June and July to around 10 micrograms chlorophyll a cm⁻² week⁻¹ and is related to incident light. Conversely, phytoplankton blooms were delayed until August and September when hydrographic conditions were optimum for biomass accumulations of from 30-70 micrograms chlorophyll a/liter.

Maximum growth of periphytic and planktonic algae occurred at the same location in the estuary. This similarity in spatial distribution is not directly related to hydrographic conditions since the periphyton algae are sessile and more resistant to washout. The water in this section of the estuary presumably contained a more adequate supply of one or more limiting nutrients than water from adjacent locations.

Value of Information: 4

Comments: None

OTHER AQUATIC RESOURCES

Welch, E.G. (U.S. Geological Survey), and G.W. Isaac (Municipality of Metropolitan Seattle). March 1967. Chlorophyll variation with tide and with plankton productivity in an estuary. Journal of Water Pollution Control Federation, Part 1, Vol. 39:360-366.

Source of Information: University of Washington, Fisheries-Oceanography Library

Area of Study: Duwamish River estuary, lower 13.1 miles of river

As part of a monitoring program to determine the influence of sewage treatment plant effluent on production and standing stock of plankton, this investigation was performed to study the relationship between tidal stage, standing crop, and productivity. Water samples were collected in September and November 1964, and in January and June, 1965. Samples were analyzed for chlorophyll a and specific conductance. Primary productivity was measured in situ by the light-dark bottle technique to determine whether or not chlorophyll a is a good measure of plankton standing stock.

Chlorophyll a concentrations is inversely correlated with tidal stage in the Duwamish estuary at most times when inverse correlations occur between chlorophyll a and specific conductance. The correlation is most pronounced in the central part of the estuary, during periods when river discharge is sufficiently low to permit sizable tidal changes in specific conductance.

Measured chlorophyll a is usually active in photosynthesis, and therefore is a reliable indicator of phytoplankton standing stock, as shown by a highly significant correlation between chlorophyll a and gross productivity. This relation is not predictable at high river discharge, because the scouring effect in the upstream channel can introduce chlorophyll that is photosynthetically inactive and therefore not a reliable phytoplankton measure.

Value of Information: 2

Comments: None

OTHER AQUATIC RESOURCES

Young, C.C. September 13, 1976. Proposed Declaration of Non-Significance.
City of Seattle, Department of Community Development, 17 pages.

Source of Information: Seattle Municipal Library

Area of Study: 1022 South Monroe Street, Seattle

This proposed DNS to place approximately 300 tons of rock riprap along a 260-foot stretch of the Duwamish Waterway on an eroded site to provide uplands protection indicates no negative impacts to the environment, including no effects on existing fauna or wildlife habitats. The report is a questionnaire with "yes" and "no" answers; no data are given.

Value of Information: 3

Comments: None

OTHER AQUATIC RESOURCES

Zeigler, B. 1978. Definition of alternative forms of development for Terminal 107 (Kellogg Island) and vicinity (Draft): Letter of Comment. Washington Department of Game, Olympia, Washington, 3 pages.

Source of Information: Leslie Lynam

Area of Study: Duwamish Waterway

Stated that juvenile salmonids rely on the shallow water surrounding Kellogg Island for safe seaward migrations, and a diversity of bird species nest and feed on the island and its surrounding waters. A list of 30 bird species and one mammal species was attached (data from 12-4-77 and 4-11-78).

None of the alternatives were thought to protect existing fish and wildlife. Recommended that final decision making on the proposal be postponed until environmental studies were completed.

Value of Information: 3

Comments: None

E. BIBLIOGRAPHIES AND GENERAL INFORMATION

SUMMARY

Literature reviews and environmental statements are included in this section when references or data are non-specific for land use, water quality, aquatic biology, or wildlife elements.

Literature reviews relative to the study area are Smith and Snyder (1976), Collias and Andreeva (1977), and MESA, Puget Sound Project (1980). Many of the published reports evaluated in this bibliography were referenced in one or more of these documents.

Also listed are the generalized atlas documents (i.e. Youngman, 1979) and planning studies (i.e. U.S. Army Corps of Engineers, 1979a) which are useful in offering broad-based overviews of the study site.

While most of the environmental statements utilize existing data, in a few cases new data have been generated or pre-existing information applied to a site-specific assessment. The "West Seattle Bridge Final Environmental Impact Statement" (Seattle, 1979) and "Seattle Harbor Navigation Project Operations and Maintenance, EIS Supplement" (U.S. Army Corps of Engineers, 1979b) provide the most complete analyses of existing environmental conditions.

INFORMATION SOURCES

(Same as in Sections A-D)

Collias, E.E. and S.E. Andreeva. 1977. Puget Sound Marine Environment; an Annotated Bibliography. Washington Sea Grant Program, WSG 77-2. Department of Oceanography. University of Washington. 392 pp.

Source of Information: SAI Library

Area of Study: Puget Sound and Strait of Juan de Fuca

A review of books, journal articles and technical reports concerned with marine-related topics in the Puget Sound Basin. Primarily marine, but also includes some reports from the Duwamish-Green River and Lake Washington-Cedar River watersheds. All citations are cross-indexed and are usually followed by a short abstract.

Value of Information: 5

Comments: This is a revised update of an earlier annotated bibliography. Annotations usually do not provide site-specific data.

King County. November 1970. The Upper Green River Valley: An Ecological Study. Department of Planning, 74 pp.

Source of Information: Bellevue Public Library

Area of Study: Upper Green River between Flaming Geyser State Park and Auburn

The study was initiated by request of the King County Planning Commission after receipt of an application for a Planned Unit Development appearing to be contrary to the King County Comprehensive Plan of 1964 and by concern for the need to update the Comprehensive Plan. Land use and water quality are stressed in the study, along with fish resources. Numerous tables, black and white photographs, and fold-out maps are included to summarize information.

Value of Information: 1

Comments: More applicable to Green River than Duwamish. Data on fish runs, detailed summary of municipal and industrial wastes.

Local newspapers and periodicals. 1975 to 1977.

Source of Information: Northwest Collection, Suzzallo Library, University
of Washington

Area of Study: Kellogg Island

Value of Information: 3

Comments: This file contains variety of short news articles relating to
development of Kellogg Island and its utilization by waterfowl.

MESA, Puget Sound Project. 1980. Status of Knowledge and Conceptual Representation of Puget Sound Marine Ecosystems. URS, Inc., Seattle, WA.

Source of Information: URS, Inc., Seattle, WA.

Area of Study: Puget Sound

A comprehensive review of existing reports and data relative to the aquatic environment of Puget Sound. Subject areas include pelagic and benthic biology, physical oceanography, water quality and distribution of toxicants, and impacts of various marine-related activities and processes on the ecosystem.

Value of Information: 5

Comments: Report will be available on or about October 1980.

Pacific Northwest River Basins Commission. 1971. Comprehensive Study of Water and Related Land Resources, Puget Sound and Adjacent Water. Summary Report. Report Planning Committee, Puget Sound Task Force.

Source of Information: SAI Library

Area of Study: Puget Sound and Adjacent Waters

This report describes the expected needs of the Puget Sound Area's future population for water and related land resources projected to the year 2020 and presents a comprehensive plan for meeting these needs. This plan is intended as a guide to the future use of water and related land resources. Along with a plan and alternatives, a discussion of the effects of the plan on the area and the requirements of implementation are included together with the conclusions and recommendations of the Puget Sound Task Force. The published volumes include the following

- I. Digest of Public Hearings
- II. Political and Legislative Environment
- III. Hydrology and Natural Environment
- IV. Economic Environment
- V. Water-Related Land Resources
 - a. Agriculture
 - b. Forests
 - c. Minerals
 - d. Intensive Land Use
 - e. Future Land Use
- VI. Municipal and Industrial Water Supply
- VII. Irrigation
- VIII. Navigation
- IX. Power
- XI. Fish and Wildlife
- XII. Flood Control
- XIII. Water Quality Control
- XIV. Watershed Management
- XV. Plan Formulation

Value of Information: 3

Comments: Somewhat out-of-date, but Appendices III, V, VIII, XI, and XII are still generally pertinent. See also pages D-24 and A-19.

Port of Seattle. June 1975. Pier 2 - Railway Transfer Ramp Expansion Project, Final EIS. 26 pp. w/appendices.

Source of Information: Seattle Municipal Library

Area of Study: Pier 2 on Elliott Bay

This EIS reports on the filling of two small embayments on the shoreline face of Pier 2. The biota of the area is described, and it was determined by the Department of Fisheries that this project and proposed fill at Pier 1 would have no adverse effects on loss of habitat to juvenile salmon. Bottom samples were analyzed to determine flora and fauna, and marine worms were dominant. The diversity of marine species in the vicinity of Pier 2 was lower than that reported by Harman and Serwold (1974) for deeper and less altered environs of Elliott Bay. Pier 2 sediments provided a poor habitat for benthic organisms.

Value of Information: 3

Comments: See also pages A-52 and D-14.

Port of Seattle. August 1976. Proposed Terminal 37 Expansion Project
Southeast Harbor Area, Final EIS.

Source of Information: Seattle Municipal Library

Area of Study: Southeast corner of Elliott Bay, between Piers 37 and 42

Additional cargo yard area would be provided by filling approximately 15 acres of open water and 8 acres of water beneath existing aprons or platforms. No adverse impacts on upland fauna would be likely. Permanent reduction in marine habitats of about 23 acres would adversely affect species directly dependent on them. No impacts on rare or endangered species would occur. The only existing upland fauna consists of pest varieties, such as rats and mice, and shorebirds and urban bird species at times. Benthic organisms are described, using material from Southeast Harbor Environmental and Assessment of Impacts (Parametrix, 1976).

Value of Information: 4

Comments: Draft EIS also available (April 1976). See also page A-54.

Seattle, City of. 1976. Final Environmental Impact Statement for Commercial Wharf Development. Department of Community Development, Environmental Management Division. 50 pages.

Source of Information: Seattle Public Library

Area of Study: East bank of Duwamish, 4615 Diagonal Avenue South

This statement assesses the impact of construction of a commercial wharf, parking area, office, warehouse buildings, and loading areas, and dredging of the property on the east bank of the Duwamish River at 4615 Diagonal Avenue South, Seattle. Unavoidable adverse impacts noted are that the removal of upland vegetation will completely eliminate an upland habitat used by several species of common city birds and ground animals and deprive ducks in the area of a common dietary resource.

At present, approximately 70% of the property is covered by vegetation and the site is unusual in that it provides a habitat for animals not normally found in an industrial area. Field investigations revealed that the area is inhabited by birds (a list of observed species on Kellogg Island and immediate vicinity, 1974-1975, is included), rabbits, snakes, and insects, and probably amphibians such as frogs, toads and salamanders exist in the pits. The bird habitat of the Chiyoda site is described.

Value of Information: 5

Comments: See also page A-58.

Seattle, City of. 1979. West Seattle Bridge Final Environmental Impact Statement. Federal Highway Administration, State Department of Transportation, Seattle Engineering Department, 624 pages.

Source of Information: Seattle Public Library

Area of Study: Spokane Street Corridor over Duwamish

This statement assesses the impacts of construction of a replacement bridge structure for the West Seattle Corridor across the East and West Waterways of the Duwamish River and across Harbor Island. Existing elements of the physical and human environments are discussed, along with economic conditions, land use planning, and an assessment of alternative proposed structures. Terrestrial fauna of Puget Ridge, including mammals and birds, is described, the utilization of Kellogg Island by nesting, overwintering and transient birds is noted, and benthic fauna of the East Waterway and from pilings and riprap in the Southeast Harbor are documented. Sampling studies conducted in 1975 by otter trawl are detailed for two sampling stations, one on each side of the Spokane Street Bridge, and 29 non-salmonid fish species were collected. Wildlife, fishery, and benthic studies in the area of Kellogg Island, have been commissioned by the Port of Seattle, but results were not available for this report. It is noted that fishermen catch starry flounder, English sole, and pile perch in the East Waterway. No rare or endangered species are present in either the marine or terrestrial habitats of the study area. A major adverse impact of the proposed action is the potential loss of marine and shoreline habitat and dependent resources in the Duwamish if the waterway is improperly upgraded to better serve deep water navigation.

Value of Information: 5

Comments: None

Smith, S. Y. and G. Synder. 1976. An annotated bibliography on the Duwamish River - Elliott Bay Complex. NMFS, Environmental Conservation Division; USACE, Waterways Experiment Station.

Source of Information: NMFS, Montlake Lab

Area of Study: Duwamish, Elliott Bay

This annotated bibliography was compiled for the Dredged Materials Research Program of the Waterways Experiment Station (WES) and relates to an on-going study of effects of the disposal of dredged material into Elliott Bay, selected marine organisms with special reference to the uptake of polychlorinated biphenyls (PCB's) and trace metals. This bibliography was prepared from current literature (since 1965) with a few exceptions for earlier pertinent work. No attempt was made to include foreign language publications or abstracts on dredge or disposal studies; Ellinger and Snyder (1965) recently completed an annotated bibliography of effects of dredging and dredge spoils on aquatic organisms in the Pacific Northwest. Furthermore, due to the large volume of information on other phases of the problem, such as methods of analysis, industrial uses, and earlier publications, the reader is referred to the bibliographies and selected reference material listed herein.

The bibliography is divided into seven sections. The first contains references on the physical descriptions of the Duwamish River - Elliott Bay complex such as circulation and mixing, sediment transport and water quality. Other references specifically concerned with biological communities in either the Duwamish River or Elliott Bay are also included here.

The second section to seventh sections contains specific or general information on the biological communities of benthic and pelagic organisms in Puget Sound and the Northeast Pacific Ocean.

Value of Information: 5

Comments: None

U.S. Army Corps of Engineers. 1972. Alternatives and their pros and cons
East, West, and Duwamish Waterways, Seattle Harbor, Washington, public
brochure. USACE, Seattle District.

Source of Information: U.S. Fish and Wildlife Service, Ecological Services,
Olympia, N. Nelson

Area of Study: East, West, and Duwamish Waterways

Value of Information: 2

Comments: General and older material relative to preliminary studies of
alternative development plans.

U.S. Army Corps of Engineers. 1974. Urban Runoff and Basin Drainage Study, Green and Cedar River Basins of Washington. U.S. Army Corps of Engineers, Seattle District.

Source of Information: Forestry Library, University of Washington

Area of Study: Green and Cedar River Basins

Four studies relating to factors influencing water quality for water pollution control were conducted under the auspices of the River Basin Coordinating Committee (RIBCO), an organization representing more than 60 communities and special purpose districts. This study deals with urban runoff and basin drainage in the Green and Cedar River Basins. Information is mainly limited to drainage problems, with land use patterns and water use discussed as a part of the description of the study area. Limited generalized information is given on fisheries and marine fauna, and there is no specific reference to the Duwamish study area.

Value of Information: 1

Comments: None

U.S. Army Corps of Engineers. 1979a. River of Green. Planning Division,
U.S. Army Corps of Engineers, Seattle District, pages numbered by
section.

Source of Information: Seattle Municipal Library

Area of Study: Green River

This study documents resources of the Green River and points out some of its problems and proposes some solutions. The following types of information are provided for use by local, state, and federal agencies: river geomorphology, potential park sites and trail routes, riverside land use guidelines for the lower valley, issues, valuable habitats and natural resources, including an inventory of all Lower Valley wetlands, schematic development concepts for county parks, and guidelines for diking. Technical appendices include information on aquatic and terrestrial biology (these appendices are printed separately). The Lower Green is designated as a corridor rather than a spawning ground for steelhead and salmon. The river is described as a feeding ground for heron, and river otter, muskrat and weasel can be found. Riverside "natural areas" below Horsehead Bend are rare enough to be described as "fossil" resources of extreme value. The most outstanding habitat types in the Lower Valley are the wetlands, located on the Pacific Flyway. Significant Lower Valley habitats are mapped and described in Appendix C of the main report.

Value of Information: 3

Comments: A 15 minute narrated slide show is also available. There are separate appendices on aquatic and terrestrial biology, these were not available for review.

U.S. Army Corps of Engineers. 1979b. Seattle Harbor Navigation Project Operations and Maintenance, EIS Supplement. U.S. Army Corps of Engineers, Seattle District.

Source of Information: Seattle Municipal and GRA Libraries

Area of Study: Elliott Bay, East, West, and Duwamish Waterways

The proposed action is continued maintenance dredging of the Seattle Harbor Navigation Project as authorized, to be conducted annually, and the disposal of the dredge materials into Elliott Bay. Detailed description of the environmental setting is given including information on the biological systems. Benthic organisms inhabiting the Duwamish Waterway are tabulated, 1) along with Kellogg Island and Duwamish Waterway bird observations, 2) and the importance of Kellogg Island as a wildlife and waterfowl habitat is noted. Benthic organisms are described in relation to their habitat, and characteristic flora and fauna of the Seattle Harbor are diagrammed. No known threatened or endangered species are noted for either the dredging or disposal sites.

The primary impact of both the dredging and disposal operations involves habitat disruption, which may be either temporary or permanent. Both actions displace or kill resident species populations and can potentially affect migratory species. The primary direct effects of dredging on bottom-dwelling organisms in the waterway are: (1) physical removal and partial destruction of organisms living in the channel areas dredged, and (2) effects caused by changes in water conditions during dredging operations. The benthic invertebrates provide a food source for bottom-feeding fish which may inhabit the area. The loss of these invertebrate populations will reduce the available feeding area for bottom-feeding organisms.

Value of Information: 5

Comments: None

U.S. Environmental Protection Agency. June 13, 1975. Auburn Interceptor
(Green River Sewerage Area) Final Environmental Impact Statement. EPA
project #C-530475-02, 258 pages plus appendices.

Source of Information: Seattle Municipal Library

Area of Study: Auburn Interceptor

This EIS contains a description of natural vegetation, wildlife, and fisheries in the Green River Sewerage Area. Although the site is not located directly on the river, Table 11 is referenced as it lists rare, threatened, or endangered species whose range includes the Green River sewerage area. Most of the birds in the table have been observed in the study area by local biologists and birdwatchers. Amphibians, birds, and mammals are listed, and it is possible some of them could be found further downstream in the Duwamish study area. Appendix D of this report is a species list of fauna of the sewerage area, including amphibians and reptiles, birds, and mammals.

Value of Information: 2

Comments: None

U.S. Fish and Wildlife Service. 1976. Assessment of effects of altered stream flow characteristics on fish and wildlife, Volume I, Pacific Northwest Region case studies. Enviro Control, Inc., Rockville, Maryland.

Source of Information: Forestry Library, University of Washington, on microfiche

Area of Study: Green River

Assessments apply to stream flow characteristics immediately below Howard Hanson Dam, especially to illustrate the interactions of water needs for fisheries and municipal (City of Tacoma) water needs. Conducted as part of a regional study with case studies on a number of projects in Washington and other Western states. Includes a detailed analysis of the factors observed to be affecting fish and wildlife.

Value of Information: 2

Comments: Not directly applicable to Duwamish River.

Washington Department of Ecology. 1973. Bibliography of Bibliographies on Water Resources and Basin Bibliographies: Central Puget Sound Basin Bibliography. Water Resources Information System, Basin Bibliography No. 20, 24 pages.

Source of Information: METRO

Area of Study: State of Washington

Value of Information: 1

Comments: Central Sound Basin Bib. lists 293 references for water resources in the area.

Washington Department of Ecology. 1977. Washington coastal areas of major biological significance. Mathematical Sciences Northwest, Inc.

Source of Information: University of Washinton, Fisheries-Oceanography Library

Area of Study: Coastal marine waters - Elliott Bay

Elliott Bay is shown as an "important" area for Canvasback and Greater Scaup during the winter. No other local data are given.

Value of Information: 2

Comments: This is a very general document with an emphasis on non-urbanized waters.

Washington Department of Natural Resources. October 1972. Washington Marine Atlas. Division of Surveys and Marine Land Management, Vol. 2, South Inland Waters.

Source of Information: Fisheries-Oceanography, University of Washington

Area of Study: Puget Sound South Inland Waters - general

The Washington Marine Atlas is a graphic compilation of existing information on marine activities and the marine environment of Washington state.

The Atlas contains information on: Oceanographic; wind; shellfish distribution; sport and commercial fishing; waterfowl distribution; water quality; public recreational areas; commercial marine traffic; oil and log handling facilities; shoreline zoning; sediment distribution; and aquatic land use allocation.

Value of Information: 1

Comments: It is useful as a general reference.

Youngman, C., editor (Department of Geography, University of Washington).
July 1979. Coastal Zone Atlas of Washington. Washington State Department of Ecology, Vol. 6 - King County.

Source of Information: Fisheries-Oceanography Library, University of Wash.

Area of Study: King County

This is a collection of detailed coastal maps of King County followed by nine pages of text describing in detail coastal geology, slope stability, coastal drift sectors, sand and gravel resources, coastal flooding, critical biological areas, and land cover/land use. Critical faunal areas are described, and detailed descriptions of several species of birds, fish, and invertebrates are given. Elliott Bay is indicated as a critical biological area for canvasback and greater scaup in the winter season.

Value of Information: 3

Comments: Useful as a general reference.

F. DATA ON FILE

Municipality of Metropolitan Seattle

Municipality of Metropolitan Seattle (METRO)

Data on file at METRO regarding the Duwamish River and Elliott Bay include operational data for the Renton Treatment Plant and water quality monitoring of selected stations within the drainage area. The following citations list the specific monitoring programs conducted by METRO. Raw data can be retrieved through the METRO computer system.

DATA ON FILE

Metro. 1970. Green-Duwamish River Water Quality Sampling, prior to 1970. Raw water quality data from Municipality of Metropolitan Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 3

Sample Period:

1966-1970 (The most intense sampling occurred in 1966)

Stations:

301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311
(see attached for station locations)

Parameters:

DO, Temp., Conductivity, Total Coliforms, Nutrients
(a variety of forms)

Number of Observations:

Approximately 2,871

These data do not represent a consistent sampling program, but rather is a collection of bits and pieces. Stations, dates and parameters are indicated. Very little is known about this data concerning methods, accuracy, etc. Note: Older data were collected by Metro, but was not put into the data collection.

Metro, 1972. Puget Sound Productivity Studies in Elliott Bay.
Raw water quality data from Municipality of Metropolitan
Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 3

Sampling Period:

1968-1972

Sampling Locations:

174 (Surface and depths)

Parameters:

Temp., DO, Transparency, Salinity, $\text{NO}_3\text{-NO}_2$, Hydrolyzable
P., Chlorophyll a, Productivity, Wind Speed, Solar Radiation,
Silica

Frequency:

Weekly, March to September

Number of Observations:

Approximately 560

Metro. 1975-1976. Water Quality Review Board six month report
(October, 1975-March 1976). Municipality of Metropolitan
Seattle. Seattle, Washington (unpublished data).

Source of Information: Metro Data Retrieval

Value of Information: 3

Metro, 1976a. Elliott Bay water quality sampling; 1968 to 1976.
Part I. Raw water quality data from Municipality of Metropolitan Seattle.

Source of Information: Metro data retrieval

Value of Information: 3

Sampling Period:

January 1968 to March 1976

Sampling Locations:

181*, 182*, 183*, 184*, 188, 189, 1741, 195
(*Depth profiles)

Parameters:

Temp., DO,* Transparency, Salinity,* Total and Fecal Coli
(*at 181, 182, 183 and 184 only)

Frequency:

Twice monthly

Number of Observations:

Approximately 3200

DATA ON FILE

Metro, 1976b Green/Duwamish River Water Quality Sampling; 1970-1976. Part I. Raw water quality data from Municipality of Metropolitan Seattle.

Source of Information: Metro data retrieval

Value of Information: 4

Sampling period:

July, 1970 to March, 1976

Sampling Locations: (see attached for station locations)

304, 305, 306, 307, 3077, 308, 3081, 309, 3091, 310, 3106, 311, 3107, 351, 3108, 312, 313, 3132, 315

Parameters:

Temperature, total coli, fecal coli, $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-NO}_2\text{-N}$.
Total $\text{PO}_4\text{-O}^*$, chlorine residual (311 and 3106)**
Hydralyzable $\text{PO}_4\text{-O}^*$

Sampling Method:

Grab samples were taken approximately 1 m from the surface. At stations 305, 306 and 307, bottom samples were taken for nutrients and temperature using a Van Doren.

Frequency:

Twice monthly

Number of Observations:

Approximately 6000

The accuracy of these data are unknown.

* Changed from hydrolyzable to total in 2/75

** Started in January, 1975

Metro, 1976c. Green/Duwamish River Water Quality Sampling;
1970-1976. Part II. Raw water quality data from Municipality
of Metropolitan Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 3

Sampling Period: May 1970 to March 1976 (see list of Green-
Duwanish station locations)

Sampling Stations:

301, 302, 303, 304

Parameters:

Temperature, DO (301), chlorinity (301), conductivity (301),
total and fecal coli

Sampling Method:

Grab samples were taken approximately 1 m from the surface.
A depth profile (1, 5 and 10 m) was taken at 301 using a
Van Doren.

Frequency:

Twice monthly

Metro, 1978. Green River Water Quality Sampling; Automatic Monitoring Program, 1964 to 1978. Raw water quality data from Municipality of Metropolitan Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 3

Sampling Period:

9/64 to 12/76 - 305 and 309
9/64 to 3/78 - 307, 311 and A319

Sampling Locations:

Spokane Street (305), Surface and bottom
16th Ave. S. (307), Surface and bottom
E. Marginal Way (309), Surface only
Renton Junction (311), Surface only
Auburn (at Hwy. 18 just south of Green River/Soos Creek
Confluence) (A319), Surface only

Parameters:

Conductivity, dissolved oxygen, pH, temperature, salinity,
salinity, solar radiation (309)

Methods:

A remote automatic sampling unit is permanently installed at each location. Samples are taken from 1 m below the surface and 1 m above the bottom and as close to the middle of the channel as possible.

Frequency:

Samples are taken hourly; daily summaries are available.

Metro, 1980a. Elliott Bay water quality sampling; 1968 to 1976:
Part II. Raw water quality data from Municipality of Metro-
politan Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 4

Sampling Period:

April, 1976 to present

Sampling Locations:

181*, 182*, 183*, 184*, 188 (*Depth profiles)

Parameters:

Temp, DO*, Transparency, Salinity*, Total and Fecal Coli
(*at 181, 182, 183, 184 only)

Frequency:

Quarterly

Number of Observations:

Approximately 210

DATA ON FILE

Metro, 1980b. Green River water quality sampling, Rival project description. Raw water quality data from Municipality of Metropolitan Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 4

Sampling Period:

April 1976 to present

Sampling Locations: (see attached for station locations)

Green Duwamish: 0305, 0307, 0309, 3106, 0311, 0315, A319
B319

Parameters:

Total coli, fecal coli, chlorine residual (311 and 3106), conductivity, dissolved oxygen, $\text{NH}_3\text{-N}$, Kieldahl N, (311 & 3106), $\text{NO}_3\text{-NO}_2\text{-N}$, pH, Total $\text{PO}_4\text{-P}^*$, total suspended solids, temperature, turbidity, lead, zinc, cadmium, copper, chromium, mercury, nickel.

Sampling Method:

Grab samples are taken at approximately 1 m

Frequency:

Twice monthly May to September
Monthly October to April
Quarterly - Metals

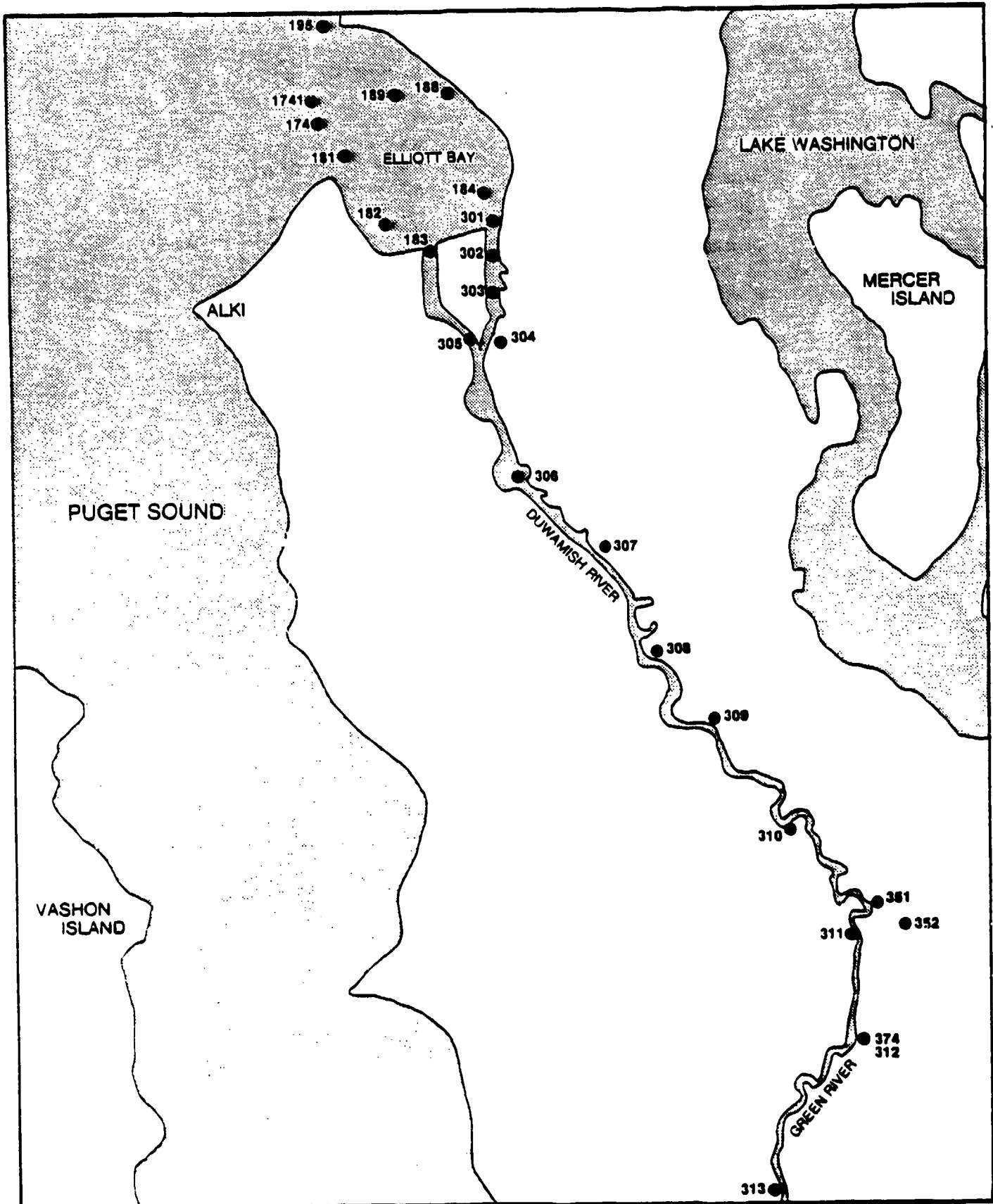
Observations:

Approximately 1300

*Changed from 13th Ed to 14th Ed (Standard Methods) in 9/76.

STATION LOCATIONS FROM MOUTH TO TUKWILA

0301	Duwamish River	E. Waterway Mouth
0302	Duwamish River	E. Waterway Pier 28
0303	Duwamish River	E. Waterway Pier 25
0304	Duwamish River	E. WW Spokane St. Bridge
0305	Duwamish River	W. WW Spokane St. Bridge
0306	Duwamish River	1st Ave. S. Bridge
0307	Duwamish River	16th Ave. S. Bridge
3077	Rainier Vista Eff	
0308	Duwamish River	Boeing Bridge
3081	Duwamish River	Highway 99 Bridge
0309	Duwamish River	E. Marginal Way Bridge
3091	Duwamish River	42nd Ave. S. Bridge
0310	Duwamish River	56th Ave. S. Bridge
3106	Duwamish River	Fort Dent Park
3107	Green River	Below Rip Outfall
0351	Renton TP Eff	At End of Chlorine Contact Channel
3108	Green River	Above Rip Outfall
0311	Green River	Renton Junction Bridge



Location of Metro's water quality stations.

INDIAN TRIBES

Muckleshoot Indian Tribe. Information on file.

Source of Information: Dennis Moore, Muckleshoot Indian Tribe

Area of Study: Green-Duwamish River

The Muckleshoot Indian Tribe has maintained complete catch and effort records for the Tribal fishery since 1977. Incomplete records for the Tribal fishery are available for years prior to 1977.

The tribe began a salmon enhancement program in the 1975-1976 brood year with a chum salmon stock from the Quilcene River. Since 1976 the chum rearing program has been carried out with the Hoodspout stock of chum salmon. The chum enhancement program is currently rearing 1 to 1.5 million chum fry per year with a goal of 2 million. The tribe also reared coho salmon from 1976-1977 through 1978-1979. In 1979-1980 this program was switched to fall chinook production with an eventual goal of 2 million fish. Existing capacity for rearing fall chinook is about 500,000.

The tribe is currently conducting artificial substrate experiments to determine the best substrate and density for tribal rearing boxes.

In 1978 the tribe conducted an evaluation of the adult fish ladder and juvenile salmon air lift facility at the Black River Pumping Station.

Value of Information: 3

Comments: None

State Agencies

Washington State Department of Ecology has a computerized information storage and retrieval system, Water Resources Information System (WRIS)

WRIS is a centralized source of information on Washington State's water and related resources. WRIS is designed to meet the information needs of private citizens and interest groups as well as city, county, state, and federal agencies - anyone involved in planning for the most effective and beneficial use of Washington's water resources.

It is a bibliographic file on all water-related information in the state. It does not store or retrieve water resources data, although this capability has been considered for addition to WRIS at a later date.

Each document entry provides information on author, title, date of publication, pages, publisher, location of document, and usually an abstract. The information can presently be retrieved by geographic areas (3), Water Resources Inventory Areas (62), and subject, or keywords (16), or a combination of these using Boolean logic. At a later date it may become possible to retrieve by author or title, also.

The system provides bibliographies of available materials on the subjects chosen by the user. The list will include materials available in the Ecology Library, other local governmental libraries, and in certain public and private collections.

Washington Dept. of Fisheries, Hatchery Division. Data on file.

Source of Information: Wash. Dept. Fish., Olympia, Washington

Value of Information: 2

The Hatchery Division of Wash. Dept. Fish. keeps on file the records of number of returning fish, egg take, and hatchery plants. This information for the Green River Hatchery is summarized in annual reports for Washington hatcheries.

DATA ON FILE

Washington Department of Game. 1980. Data on file. Washington Department of Game, Seattle, Washington.

Source of Information: Washington Department of Game, Seattle

Value of Information: 1

Washington Department of Game has responsibility for steel-head management on the Green River. Records on file include harvest data from 1961 to present and planting data for winter fish from 1960 to present and for summer fish from 1964 to present. Progress reports are issued about four times a year and include statistics and any research that has been conducted.

DATA ON FILE

Federal Agencies

U.S. Army Corps of Engineers, Duwamish Navigation File

Source of Information: Washington State Department of Fish and Game,
Olympia

Value of Information: 3

This office file of materials relating to the Corps of Engineers Duwamish Navigation Project contains notes, correspondence, minutes of meetings, permits, bibliographies and studies, including fish harvest records. No new material related to the project was found in going through the file. (This is an office file made available by Leslie Lynam of Fish & Game)

U.S. Army Corps of Engineers. March 1972. Summary - Checkpoint 1
Report, Duwamish Waterway, Seattle Harbor, Washington. 45 pp.

Source of Information: USFWS, Ecol. Services, Olympia (Nancy Nelson)

Value of Information: 2

The purpose of this report is to inform Division Engineer
that further study on this proposal is warranted.

DATA ON FILE

U.S. Coast Guard. Oil and hazardous material spills. Marine Safety Division, Seattle. Data on file.

Source of Information: U.S. Coast Guard Station, Pier 36, Seattle.

All oil and hazardous material spills for Puget Sound are on file with the Marine Environmental Protection Officer. Recent information on spills reported, regardless of size, are readily available to 1977. Prior reports are in Division archives.

Value of Information: 2

Comments: None

U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Environmental Research Laboratories. 1978. Marine Ecosystems Analysis Program (MESA), the Puget Sound Project, FY78 - Annual Report. Seattle, Washington, 36 pp.

Source of Information: NOAA, Western Regional Facility, Seattle.

Area of Study: Puget Sound

The purpose of the Puget Sound Project is to develop an understanding of the environmental impacts of human actions upon regional marine ecosystems and, thereby, allow predictions of the ecological consequences of those actions. This annual report summarizes MESA Puget Sound Project research, including significant findings and activities, that occurred between October 1, 1977 and September 30, 1978. The appendices to this report contain lists of project contracts and grants, principal investigators, and a bibliography of Project-sponsored publications. Among MESA research for FY78, a survey scan for toxic substances was completed in four embayments of Puget Sound (near Seattle, Tacoma, Olympia and Bremerton) in which the occurrence and concentration of trace metals, petroleum constituents, and synthetic (industrial) organic compounds in sediments were documented. The greatest total amount of extractable material was found off Pier 54 (downtown Seattle) followed in order by Upper Sinclair Inlet (Bremerton), Hylebos Waterway (Tacoma), and the Duwamish River - East Waterway (Seattle).

Value of Information: 3

Comments: This survey is an on-going project

DATA ON FILE

U.S. Environmental Protection Agency, STORET Data Retrieval, Office of External Affairs. U.S. Environmental Protection Agency Region X, Seattle, Washington.

Source of Information: U.S. EPA, STORET Retrieval, Seattle, WA

Value of Information: 3

Raw water quality data are filed in the STORET computer system of the EPA. Data from EPA, METRO, and the University of Washington stations in the Duwamish River and Elliott Bay are listed by date and parameters monitored.

Summaries of the number of observations, means, variances, standard deviations, and ranges of each parameter are given.

Also on file are the correspondence and data regarding the 255 gallon spill of PCBs in the Duwamish River. The following report was temporarily unavailable for our review, but it is on file at the Region X office.

U.S. Environmental Protection Agency. 1974. On-Scene Coordinator Report. PCB, Duwamish Waterway, Seattle, WA, U.S. EPA Region X Seattle.

DATA ON FILE

U.S. Fish and Wildlife Service

Seattle Harbor/East, West, and Duwamish Waterways Navigation File
F-3c(1), Corps of Engineers, Cedar-Green River Basins.
1973-1980.

Source of Information: U.S. Fish and Wildlife, Ecology Services,
Olympia

Value of Information: 5

This series of files available through Nancy Nelson in the Ecology Section of the U.S. Fish and Wildlife Services offices in Olympia contains correspondence, meeting notes, and drafts of U.S. Fish and Wildlife reports on the proposed navigation improvements for the East, West, and Duwamish Waterways. Some correspondence dates back to 1960. The most recent file contains correspondence on the reactivation of the Duwamish Navigation Project. Some reference material is contained in the files and has been documented elsewhere in our survey.

DATA ON FILE

U.S. Geological Survey. Information on file

Source of Information: USGS, Tacoma, Washington

Area of Study: Green-Duwamish River

The USGS has historical data on file regarding the discharge of Green-Duwamish River from several gageing stations along the river. The most important station for this study is located near Tukwila, Washington, above the tidal influence in the river.

Besides the several USGS sponsored reports reviewed for this document, the following two documents were temporarily unavailable for annotating:

Stoner, J.D., 1972. Determination of mass balance and entrainment in the stratified Duwamish River estuary, King County, Washington: U.S. Geological Survey Water-Supply Paper 1873-F, p. F1-F17.

Williams, J.R., 1967. Movement and Dispersion of Fluorescent Dye in the Duwamish River Estuary, Washington, U.S. Geological Survey Prof. Paper 575-B: 245-249.

UNIVERSITIES

University of Washington: Reports on file.

Source of Information: Department of Oceanography

Area of Study: Duwamish River Estuary, Elliott Bay

The following reports are on file at the University of Washington, Department of Oceanography, but were presently unavailable for our review:

Pavlou, S. P., K. A. Kroglund, R. N. Dexter, and J. R. Clayton. 1973. Data Report: R/V ONAR Cruises 434, 450, 469, and 502. Hydrographic, Chemical, and Biological Measurements. Special Report No. 54, Reference No. M 73-81, Department of Oceanography, University of Washington, Seattle.

Pavlou, S., R. N. Dexter, W. Hom and K. A. Kroglund. 1976. PCB Monitoring in the Duwamish River, A Study of Their Release Induced by the Dredging Activities in Slip 1. University of Washington Special Report No. 66.

Pavlou, S. P., and R. N. Dexter. 1977. Environmental Dynamics of Polychlorinated Biphenyls (PCB) in Puget Sound: Interpretations and Criteria Recommendations, Special Report No. 75, Reference No. M 77-38, Department of Oceanography, University of Washington, Seattle.

Value of Information: 3

On-Going Research

Cline, J. D., and R. A. Feely. 1979. Transport of sorbed petroleum hydrocarbons in Cook Inlet, Alaska, and the Duwamish River, Washington. Current research activities. Dept. Ocean. Univ. Wash. Ref. #A79-8. Page 56.

Source of Information: Univ. Wash. Dept. of Ocean.

Value of Information: 1

Because of the high concentrations of suspended sediments in Cook Inlet, the transport of petroleum-like hydrocarbons by this mechanism may be significant. To test this hypothesis, relatively large concentrations of suspended matter are being recovered and extracted for hydrocarbons. The presence of crude oil is being documented on the basis of n-alkane and aromatic compound patterns as well as C^{13} isotopic compositions.

Concurrently, suspended material from the Duwamish River is being analyzed. Only a few samples have been analyzed to date. Planktonic hydrocarbons and terrestrial plant waxes are dominant in the n-alkane fraction. Isotopic analyses have not been completed.

Laboratory experiments are currently underway to quantify the behavior of crude oil toward suspended detrital particles collected in Cook Inlet. Variables being investigated include temperature, salinity, particle chemistry and morphology, DOC, and the composition of the oil, particularly the concentrations of surfactants.

Preliminary data show that up to 10% of the particle weight is accommodated oil. There appears to be no fractionation of the n-alkane fraction, other than the normal loss of volatiles. The results have been modeled; the model conforms to a model similar to the Langmuir isotherm, although the process is not monomolecular.

Malins, D. C., N. L. Karrick, H. O. Hodgins, B. B. McCain, D. W. Brown, and A. K. Sparks. Characteristics and extent of biological abnormalities; identification and distribution of chemical contaminants. Compendium of Current Marine Studies in the Pacific Northwest, Oceanographic Institute of Washington.

Source of Information: Oceanographic Institute of Washington, Seattle

Value of Information: 3

This investigation is presently being conducted by the National Marine Fisheries Service, Northwest and Alaska Fisheries Center.

Six embayments in Puget Sound, consisting of four urban-associated areas (Elliott and Commencement Bays, and Budd and Sinclair Inlets), and two reference areas (Case Inlet and Port Madison), will be investigated: (1) to investigate the identity, concentration, and geographic distribution of organic contaminants (including aromatic hydrocarbons and chlorinated hydrocarbons), and trace metals in bottom sediments and in fish and invertebrates associated with these sediments; (2) to determine the frequency, geographical distribution, and pathology of externally visible abnormalities of at least 10 species of fish and 5 species of invertebrates and of microscopically detectable lesions of 4 selected species each of fish and invertebrates; (3) to compare (a) the biological characteristics (length frequency and length/weight/age relationships) of normal-appearing and abnormal individuals of the target species, and (b) various aspects of the community structure (species composition, relative abundance, species diversity, and species richness) of fishes and invertebrates from the different geographical areas investigated; and (4) to develop a data base which will eventually allow for evaluations of relationships between the pathobiological parameters described in objectives "2" and "3", and the chemical contaminant parameters given in objective "1". Another use of this data base would be in planning for further related research activities.

Malins, D. C., N. Karrick, B. B. McCain, D. W. Brown, A. K. Sparks, and H. O. Hodgins. Characteristics and extent of biological abnormalities within Puget Sound and identification and distribution of chemical contaminants. Compendium of Current Marine Studies in the Pacific Northwest, Oceanographic Inst. of Wash.

Source of Information: Oceanographic Inst. Wash., Seattle

Value of Information: 3

This study is a major part of NOAA's MESA Puget Sound Project being done by Nat. Marine Fisheries Service which will emphasize research on the kinds, sources, fates and effects of toxic substances in Puget Sound. The purpose of this particular study is to identify and determine the distribution of toxic chemicals and document the kinds and extent of biological abnormalities among fish and invertebrates. Data analyses will include examining contaminant/abnormality associations.

The research approach will involve sampling of demersal fishes, benthic invertebrates and sediments. Chemical analyses for trace metals, petroleum constituents and synthetic organics will be performed on seasonal biologic samples and once on sediment samples. Fishes and invertebrates will be examined for external and internal histologic abnormalities seasonally. Most sampling will be concentrated in the nearshore waters of Elliott Bay, Commencement Bay, Sinclair Inlet and Budd Inlet in areas most likely to be most polluted. Expected results include identification and measurement of the concentration of toxic chemicals in selected Puget Sound embayments; determination of the frequency, pathology and distribution of internal, external and blood disorders in selected organisms; examination of the relationships of biological properties of normal-appearing animals with those of animals having abnormalities; and identification of possible pollutant/disorder associations.

Metro, Green River water quality sampling, Rival project description. Raw water quality data from Municipality of Metropolitan Seattle.

Source of Information: Metro Data Retrieval

Value of Information: 4

Sampling Period:

April 1976 to present

Sampling Locations: (see attached for station locations)

Green Duwamish: 0305, 0307, 0309, 3106, 0311, 0315, A319
B319

Parameters:

Total coli, fecal coli, chlorine residual (311 and 3106), conductivity, dissolved oxygen, $\text{NH}_3\text{-N}$, Kieldahl N, (311 & 3106), $\text{NO}_3\text{-NO}_2\text{-N}$, pH, Total $\text{PO}_4\text{-P}^*$, total suspended solids, temperature, turbidity, lead, zinc, cadmium, copper, chromium, mercury, nickel.

Sampling Method:

Grab samples are taken at approximately 1 m

Frequency:

Twice monthly May to September
Monthly October to April
Quarterly - Metals

Observations:

Approximately 1300

*Changed from 13th Ed to 14th Ed (Standard Methods) in 9/76.

STATION LOCATIONS FROM MOUTH TO TUKWILA

0301	Duwamish River	E. Waterway Mouth
0302	Duwamish River	E. Waterway Pier 28
0303	Duwamish River	E. Waterway Pier 25
0304	Duwamish River	E. WW Spokane St. Bridge
0305	Duwamish River	W. WW Spokane St. Bridge
0306	Duwamish River	1st Ave. S. Bridge
0307	Duwamish River	16th Ave. S. Bridge
3077	Rainier Vista Eff	
0308	Duwamish River	Boeing Bridge
3081	Duwamish River	Highway 99 Bridge
0309	Duwamish River	E. Marginal Way Bridge
3091	Duwamish River	42nd Ave. S. Bridge
0310	Duwamish River	56th Ave. S. Bridge
3106	Duwamish River	Fort Dent Park
3107	Green River	Below Rip Outfall
0351	Renton TP Eff	At End of Chlorine Contact Channel
3108	Green River	Above Rip Outfall
0311	Green River	Renton Junction Bridge

National Oceanic and Atmospheric Administration. 1980. Current research activities of NOAA-sponsored studies.

Source of Information: NOAA, Pacific Marine Environmental Laboratories, Sand Point, Washington.

Value of Information: 3

The following NOAA-sponsored studies within the survey are currently in progress or near completion:

- (1) Battelle. 1980. Concentration of metal and organic compounds in water and suspended matter in Puget Sound. Report of the Battelle Memorial Institute for the Marine Ecosystems Analysis Program (MESA). National Oceanic and Atmospheric Administration, Seattle, Washington.

Comments: This study has just been concluded and two stations, one in the West Waterway of the Duwamish River and one in southern Elliott Bay occur within the study area.

- (2) URS. 1980. Mutagenicity assay for marine sediments in Puget Sound. Report of URS Company for the Marine Ecosystems Analysis Program (MESA). National Oceanic and Atmospheric Administration, Seattle, Washington.
- (3) Baker, F. 1980. Transport and distribution of suspended particulate matter; Elliott Bay. Studies of the Pacific Marine Environmental Laboratories. National Oceanic and Atmospheric Administration, Seattle, Washington.
- (4) NOAA. 1980. Physical transport processes in Puget Sound embayments; Elliott Bay. Studies of the Pacific Marine Environmental Laboratories. National Oceanic and Atmospheric Administration, Seattle, Washington.

Oceanographic Institute of Washington. 1979. Compendium of current marine studies in the Pacific Northwest. M.A. Metsker, ed. A publication of the Oceanographic Institute of Washington.

Source of Information: Oceanographic Institute of Washington

Value of Information: 5

This annual compendium is a descriptive record of research conducted in Washington, Oregon, and British Columbia. Sponsoring agencies include: National Oceanic and Atmospheric Administration, Municipality of Metropolitan Seattle, Washington Department of Ecology, Oceanographic Commission of Washington, U.S. Bureau of Land Management, Washington Department of Fisheries, U.S. Fish and Wildlife Service, Washington Department of Natural Resources, and U.S. Army Corps of Engineers.

The compendium disseminates valuable research information and provides a means for direct contact among researchers and managers. Project summaries are organized by subject category and indexed to provide users with an effective information tool.

Parametrix, 1980 Juvenile Salmonid Migration Study. Study for the Port of Seattle, Planning and Research Division, Seattle, Washington.

Source of Information: Parametrix, Inc., Bellevue, Washington

Value of Information: 5

This study will investigate the timing and rate of migration and food habits of juvenile salmon. Information generated by this study will be used by the Port to assess the potential effects of alternative development strategies at Terminal 91 and other sites and to measure post-construction effects of the Southeast Harbor expansion project.

The major purpose of this study will be to compare the behavior of migrating juvenile salmon along semi-natural and highly modified shorelines. The present shoreline of the estuarine reach of the Duwamish and of Elliott Bay has essentially all been modified by man's activities but can generally be divided into hard, highly modified, stable substrates such as riprap, pilings, and bulkheads; and soft, less stable substrates such as mud, sand, and gravel. Several possible adverse effects on juvenile salmon of the conversion of soft shoreline substrates to hard substrates have been suggested. Juvenile salmon may be delayed by physical barriers, may suffer increased predation if forced to enter deep water, and may be unable to adequately feed in highly modified areas. By sampling the number and length frequency of juvenile salmon at stations located from the upstream end of the estuary to the mouth of Elliott Bay on a weekly basis during the 1980 migration period (approximately March 15 through August 31), the motion and rate of growth of each species can be estimated. By analyzing reasonable numbers of stomach contents of each species at each station, food habits can be estimated. Stomach analysis of any potential predator species captured during the study may give some indication of predation.

DATA ON FILE

Port of Seattle. Terminal 91 alternative development strategy studies.

Source of Information: Port of Seattle, Planning and Research Dept.

Value of Information: 2

The Port of Seattle is sponsoring studies of impacts of future Terminal 91 development on certain aspects of the physical environment including; air quality, noise, benthic communities and resident fish communities. The objectives are to generate baseline data and assess the potential effects of various development alternatives. Concurrent studies of traffic, water quality, sediments, terrestrial biology, energy and economics will be undertaken.

Schults, D. Behavior of chemical pollutants in marine sediments.
Compendium of Current Marine Studies in the Pacific Northwest.
Oceanographic Institute of Washington.

Source of Information: Oceanographic Institute of Washington, Seattle

Value of Information: . . 3

The objectives of this study by US EPA, are to determine the chemical impact of disposal of dredged material to the marine environment. The field observation was done at the experimental dump site at the mouth of the Duwamish River in Elliott Bay, Washington. Chemical and physical parameters emphasizing heavy metals (Cd, Cr, As, Hg, Mn, Pb) were monitored before and after the disposal operation in the water column and the sediments at the disposal site and control stations. No significant chemical impact due to heavy metals was apparent at the disposal site.

Laboratory evaluations have emphasized the development of procedures which will predict the chemical impact of disposal of dredge material to marine waters. Future work will relate the chemical evaluations to bioassay criteria which are specified under Section 103 of PL 92-532 for disposal of dredged material to ocean waters.

Swartz, R. G. Puget Sound shore and offshore monitoring. Compendium of current marine studies in the Pacific Northwest, Oceanographic Inst. of Wash.

Source of Information: Oceanographic Inst. Wash., Seattle.

Value of Information: 3

The sampling program was designed by Municipality of Metropolitan Seattle (METRO) to monitor marine waters near Seattle for water quality effects of four treatment plants discharging effluent into Puget Sound. The offshore monitoring program includes biweekly sampling at relevant stations in the West Point area and quarterly sampling in Elliott Bay.

Alki, Richmond Beach and Carkeek Park outfall areas will be sampled once per quarter. Parameters measured include temperature, light transmittance, dissolved oxygen, salinity and total and fecal coliforms. Most of these parameters are measured at selected depth profile stations and near the surface.

Samples are also collected nearshore at beaches and piers along the waterfront from the Standard Oil Asphalt Plant at Richmond Beach to the Fauntleroy ferry dock south of Lincoln Park. Only temperature and total and fecal coliform counts are analyzed (bimonthly in winter and weekly in summer).

Coliform counts have improved considerably with interception of raw sewage discharges and better control of combined sewage outfalls into receiving waters. Physical and chemical parameters have remained at an excellent level with some improvement in oxygen levels near the East Waterway of the Duwamish River. Algal blooms have been noted in Puget Sound in the spring and summer, but bloom-related parameters have shown poor correlations with waste discharge.

Swartz, R. G. Green-Duwamish River monitoring. Compendium of current marine studies in the Pacific Northwest; Oceanographic Inst. of Wash.

Source of Information: Oceanographic Inst. Wash., Seattle.

Value of Information: 4

Monitoring of the Green-Duwamish River as carried out by Municipality of Metropolitan Seattle (METRO) can be divided into two phases: (1) automatic monitoring with hourly data records; and (2) biweekly manual sampling of nutrients and total and fecal coliforms. The purpose of the program is to prevent any adverse pollution effects in the river or estuary from treated waste discharges from the Renton Treatment Plant. The automatic monitoring system records dissolved oxygen, temperature, conductivity, pH and insolation levels. The studies are being conducted on a cooperative basis with the U.S. Geological Survey. The Survey has developed a mathematical model of the Duwamish estuary which will be used to study the relationship of any adverse water quality conditions in the estuary with future waste discharges from the Renton Plant.

Dissolved oxygen levels in bottom waters of the estuary have improved with the removal of most raw sewage discharges to the waterway.

University of Washington. 1979. Current research activities of the Department of Oceanography. Reference #A79-8. Dept. of Ocean. Univ. Wash., Seattle, Wash. 80 pp.

Source of Information: Univ. Wash. Dept. of Ocean.

Value of Information: 1

This document outlines current research being conducted by the U.S. Dept. of Oceanography. Information about each project includes subject, type of data to be gathered, location of work, objectives, and staff for each project. Research is broken into five main categories, biological oceanography, chemical, bio- and geochemical oceanography, geological and geophysical oceanography, physical oceanography, and applied oceanography.